DEC 15, 1938 FIRST AERO WEEKLY IN THE WORLD REGD. AT THE G.P.O. AS A NEWSPAPER

FLIGHT

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The AIRCRAFT ENGINEER AND AIRSHIPS

OFFICIAL ORGAN OF THE ROYAL AERO CLUB

Aircraft Construction Number

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The AIRCRAFT ENGINEER AND AIRSHIPS

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The Outlook

Art and Construction

THE art of designing an aeroplane is not unlike that of painting a picture. Most painters start by roughing-out the general composition, although there is one famous art school in London at which the student is allowed, if he wishes, to finish the big toe before he begins on the rest! Similarly there are aircraft designers who seem to have started with one clever bit of detail and built the rest of the aeroplane around that. But in the main, to revert to the simile of the painter, the aircraft designer starts by blocking-in the general aerodynamic design. While doing so he has at the back of his mind a clear idea of what the structure inside that outline is going to be like. He may not have settled all the details, but he will have chosen his general structural "theme."

It is because structural and aerodynamic design are so closely interrelated that we have included in this special aircraft construction number of *Flight* sections dealing with aerodynamic as well as structural design of aircraft. The one is inseparable from the other, although in the design offices there are specialists in each who do not touch the other. It is, however, the task of the chief designer to hold the scales between the demands of the two sections, and upon the skill with which he compromises depends the success of the finished aircraft.

The fundamental considerations involved are dealt with in a number of articles, and the manner in which individual designers have solved the problems which are common to all is illustrated and explained in these and other articles.

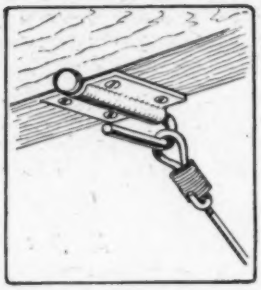
Four main features have combined to give the modern aeroplane the high aerodynamic efficiency which it possesses; retractable undercarriages; the variable-pitch airscrew; the low-drag engine cowling; and the trailing-edge flap. Between them these four are responsible for most of the improvement in efficiency, and they have, therefore, been dealt with in considerable detail. The light, powerful engines which are now available have contributed at least as large a share to performance. Consequently a section is devoted to engine progress. And, finally, controllability is of vast importance to the pilot. The summary of Professor Hill's lecture on controls and the report on the discussion of the paper, complete our review of the main features of aircraft construction as practised at the present time.

Overhauling Civil Air Transport

A GOVERNMENT White Paper announces the decision of the Air Ministry to put into practice the recommendation of the Cadman Committee by subsidising internal air lines to the extent of £100,000 per annum. All the established air lines in this country will receive a share, with a top limit of £15,000 for each company. The subsidy will be calculated at a rate of 6d. per capacity-ton-mile for the first year, falling by ½d. p.a. to 4d. in the fifth year, unless the introduction of new types is held to justify the continuance of the higher rate. Companies which only do charter work are not included. Eleven companies will benefit by the scheme, and all but one of these run for at least part of their route over the sea. This crossing of the sea is an important point, for inside the island of Great Britain it is very difficult for any air line to show a great advantage to its customers over the railway transport of the country. The air services to some of the outlying islands of our archipelago cannot achieve a heavy bulk of traffic, but such cases deserve special consideration.

At the same time the Directorate of Overseas Civil Aviation at the Air Ministry is being reorganised. Mr. Galpin has ceased to be director and Mr. Burkett is temporarily filling the post. The post of senior assistant, held by Major Villiers, has disappeared. Both Mr. Galpin and Major Villiers are now employed in the A.R.P. section of the Ministry.

"Wilbur and Orville Wright literally suspended themselves in the air on a woodscrew . . . Since those early days aircraft construction has become finicking engineering."



STRUCTURA

The Evolution of A Const
Types of Struc

By OULSE

ENORMOUS progress in the structural design of aeroplanes has been made since the days when Wilbur and Orville Wright literally suspended themselves in the air on a woodscrew. To attach the main lift wires to a plate secured to the wing spar by woodscrews would not appeal to the Airworthiness Department at Farnborough, but that is what the Wright brothers did, and they suffered no harm thereby.

Since those early days aircraft construction has become finicking engineering. The beginning was made when, somewhere about 1922, the Air Ministry decided that after the lapse of a certain number of years no more aeroplanes of the "mixed" wood and metal construction would be accepted for use in the Royal Air Force. Sight is apt to be lost nowadays of the reasons which influenced the Air Ministry in arriving at that decision. So far as can be ascertained, no official pronouncement on the subject was ever published, although doubtless the aircraft firms were informed. It is fairly safe to assume that the experience of the war period was largely responsible. Silver spruce, mostly obtained from the Pacific Coasts of America and Canada, had been the chief structural material for wing spars during the war, and the available supplies had been sadly depleted by the enormous inroads made upon them by the wholly artificial demands of the war period.

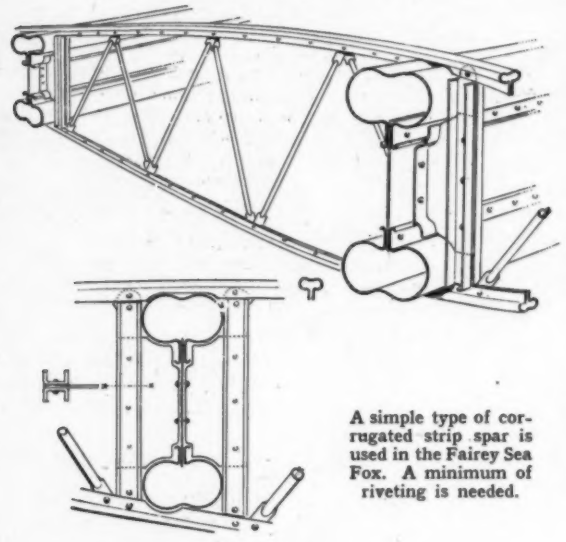
Whether or not the Air Ministry did well in stipulating that manufacturers must "go the whole hog" is, perhaps, open to argument. That this country should be dependent upon imported timber for its military aircraft was obviously undesirable, and as the available supplies were showing signs of giving out quite a good case could be made out for abandoning wood altogether. It is also possible that from fundamental considerations of the strength/weight ratios of wood and metal there may have been some idea that the metal aeroplane would be lighter for the same strength.

Early Efforts

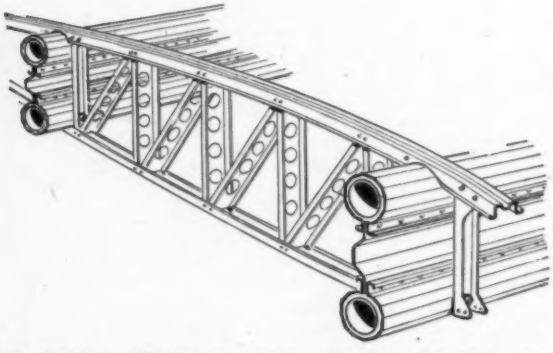
To appreciate the reasons why British all-metal aircraft construction developed in the way it did it is necessary to bear in mind that at the time when the Air Ministry made its decision to change over to metal every aeroplane in the Royal Air Force was a biplane. It was, therefore, perfectly natural that the designers should think in terms of the biplane structures to which they had been accustomed and that their first efforts should be directed towards "translating" their wood structures into metal.

Even Short Brothers, who have not been given nearly enough credit for their pioneer work in "stressed skin" construction, were at first tied to the biplane formula. At the first Olympia Aero Show after the war, in July, 1920, they exhibited a pretty little biplane, the *Silver Streak*, in which the fuselage was a pure metal monocoque. The wings were not of stressed skin type in that the usual type of spars and ribs were used, and the thin duralumin covering was but a covering, but the idea was clearly there.

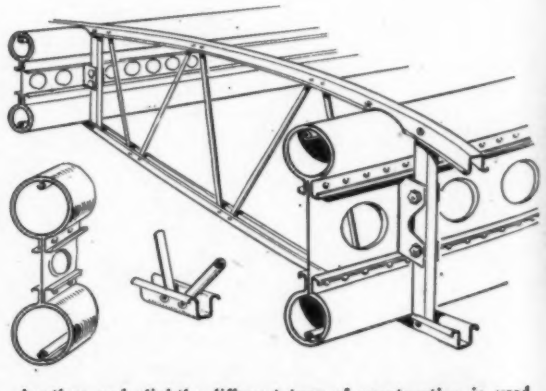
With this brief digression, let us return to the change-over from "mixed" to all-metal construction. Briefly explained, the general scheme on which designers worked was to take the old wooden structure and replace it, bit by bit, with its metal equivalent. In that way the old spindled I-section wing spar and the wooden box spar with spruce flanges and plywood walls became a box of



A simple type of corrugated strip spar is used in the Fairey Sea Fox. A minimum of riveting is needed.



In the Gloster Gladiator the sheet-metal spar web is stiffened by a corrugation running spanwise.



Another and slightly different type of construction is used in the Saro London biplane flying boat.

DESIGN

of Construction Surveyed : of Structure Compared

By OULSEN

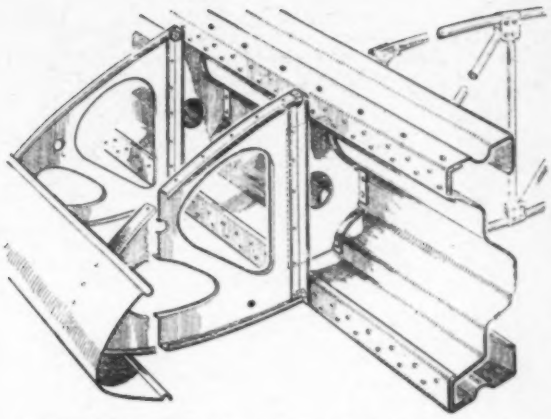
corrugated steel or duralumin, with the edges at the corners of the box riveted together. The corrugations were, of course, added in order to prevent the spar from collapsing by buckling or secondary failure long before the full compressive strength of the material had been developed.

Mention has been made of the early Short all-metal biplane. Other firms which were in the field from the very start were the Siddeley and Boulton and Paul concerns. The former produced the first all-metal military aeroplane, the Siskin single-seater fighter, and the latter had the remarkable foresight to standardise some 50 corrugated strip-steel sections, which could, by suitable combinations, be formed into wing spars of almost any dimensions likely to be used in any conceivable aeroplane. The idea behind this standardisation was that the rest of the firms in the aircraft industry would not need to spend time and money in developing their own sections, but could order their steel strip ready corrugated and in the required lengths from Boulton and Paul. In spite of its obvious merits, the idea was not taken up, and individual firms spent much time and money on learning how to roll or draw steel strip so that it left the machines straight and true. The early efforts had a distressing habit of tying themselves into knots after leaving the rolling mill or drawbench.

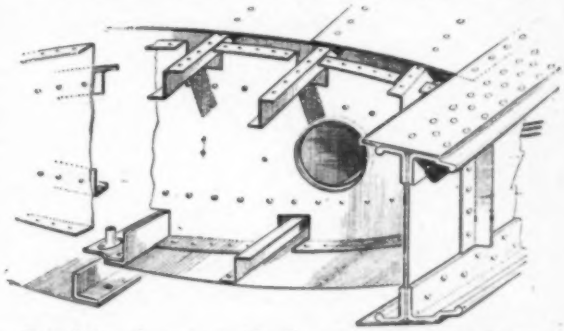
Initial Difficulties

Another initial difficulty arose from the springiness of the steel strip used. The amount of "spring-back" varied with the composition of the steel, and with the dimensions of the strip. Ultimately all these troubles were overcome, but they took time and caused delays. However, there was no expansion panic in those days, and by leaving each firm to rake its own chestnuts out of the fire it seems likely that ultimately the *very* most efficient corrugated strip construction was evolved, so perhaps there was something to be said for the apparently wasteful methods adopted.

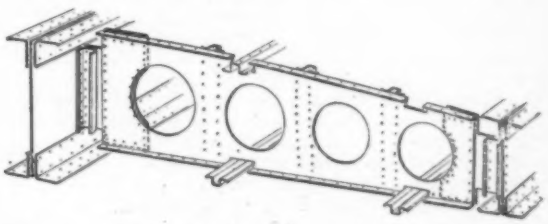
In the days of crinkled strip most firms used steel. This was due partly to the fact that from the designer's point of view it was the better material for most parts of the structure, but also partly to fear of corrosion of the aluminium alloys, the anodic protective treatment not having been put on the firm foundation which it occupies to-day.



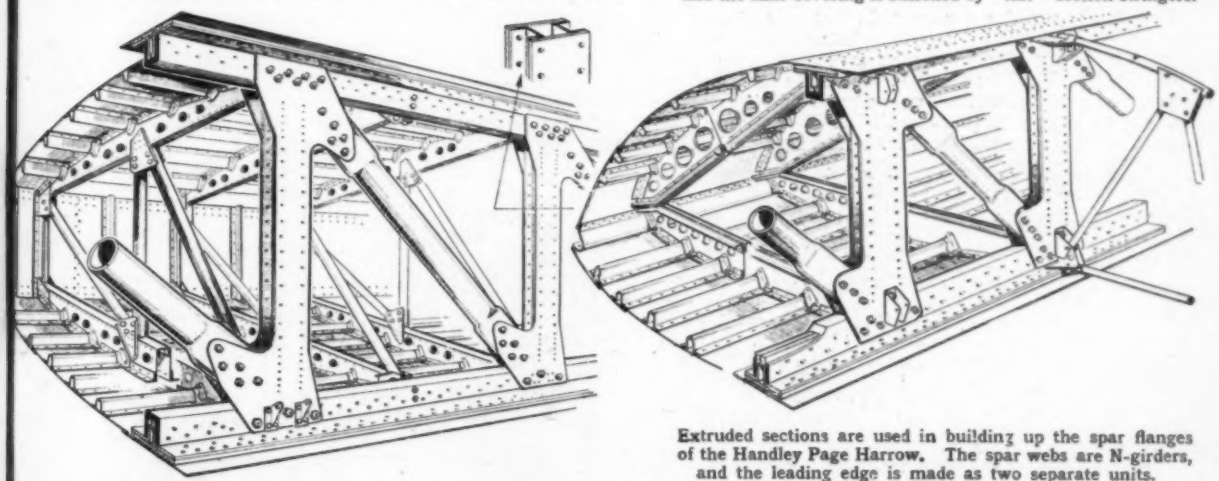
A somewhat unusual wing spar construction is used in the Supermarine Scapa biplane flying boat. The spar, known as a "Sigma" section, is built up of three corrugated strips



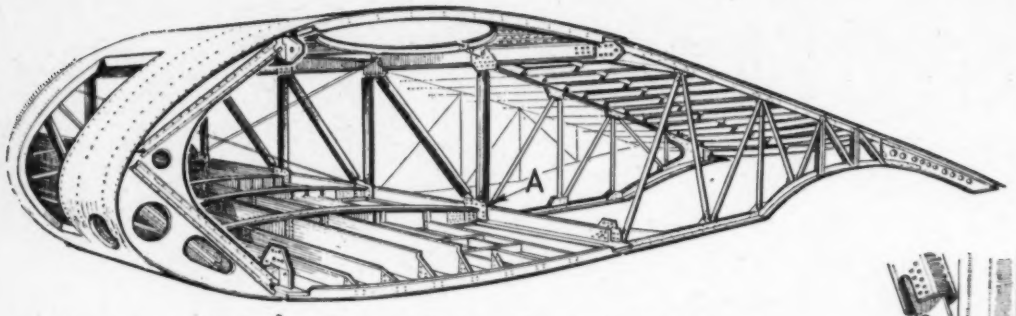
Extruded sections are used in the spar flanges of the Fairey Battle. The covering of the wing is of the stressed-skin type, stiffened by stringers of extruded Z-section, notched into the wing ribs.



The wing of the Bristol Blenheim is also of the two-spar type, and the skin-covering is stiffened by "hat"-section stringers.



Extruded sections are used in building up the spar flanges of the Handley Page Harrow. The spar webs are N-girders, and the leading edge is made as two separate units.



In the construction of fuselages of the girder type, the principle adopted was, as in the case of the wings, to replace the old wood longerons and struts by metal members. These were either cold-drawn seamless tubes or they were built up from strip formed into a tube, and possibly with lengthwise ridges formed to help stabilise the very thin walls. By buying the seamless tubing from the tube manufacturer the aircraft constructor saved himself a deal of trouble, but, on the other hand, greater uniformity of thickness was obtained from the tube built up from strip material.

Still in Use

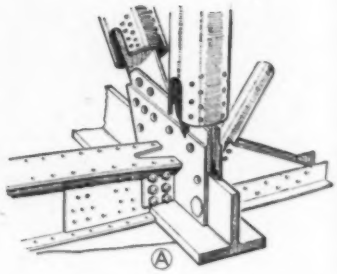
An interesting application of the drawn tube fuselage construction was that employed by the Hawker designers. The longeron tubes "started life" as circular-section tubes, but where struts and braces were to be attached flats were formed so that at intervals the longeron became of square section with rounded corners. That form of construction has survived in the Hawker Hurricane single-seater fighter. A few constructors used, and still use, welded steel tube construction.

The position when the first expansion scheme burst upon us was as outlined above. Strip and tubular construction was the order of the day, and was applied to thin-winged biplanes. Then came the demand for higher performance, and as it was expected that fabric covering might give trouble at the higher speeds contemplated, the type now known as "stressed-skin" construction became the favourite.

Many considerations influence the design of structures in which the sheet metal covering is made to carry portions of the air loads. If the designer were free to choose that system of construction which would be the most economical from the strength/weight point of view the problem would be far from simple. In addition, he has to bear in mind the need for stowage space of one sort or another inside the wings and fuselage, so it is small wonder that many variations on the same theme are to be found in modern aircraft.

Single- or Multi-spar?

While fabric covering was used the two-spar wing structure was easily the best compromise between strength and simplicity. When it came to a stressed-skin structure the problem was not quite so simple. Owing to the fact that sheet metal covering must of necessity be thin if excessive weight is to be avoided, there is little stiffness under compressive loads unless the skin is reinforced at fairly close



In the Short Empire boat the wing spars have flanges of extruded T-section, the upper and lower flanges being connected by tubular ties.

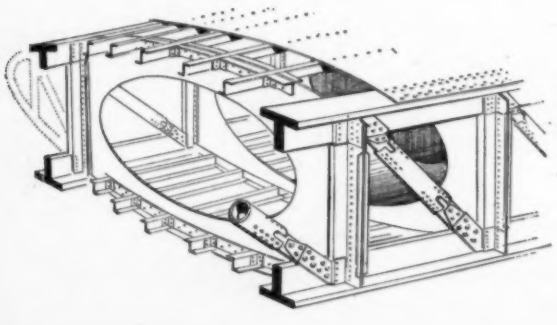
intervals so that it is divided up into quite small panels. This consideration would appear to indicate that the logical arrangement of internal wing members would be a multiplicity of spars, spaced approximately a foot apart between leading and trailing edges, and having aerofoil-section-forming ribs or diaphragms running chordwise between the spars, and spaced approximately the same distance apart.

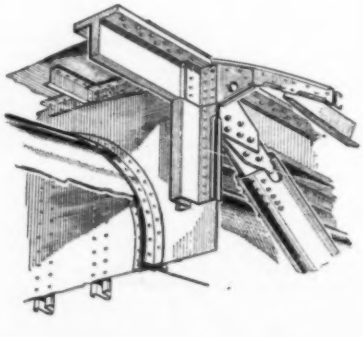
Not So Easy

Had the aircraft designer nothing to worry about except to provide the strongest possible wing structure for the lowest possible weight, this wing arrangement would probably be the most efficient. Such a wing was used by the American designer Northrop several years ago. That it has not found general application in this country is due to the fact that although the monocoque type of construction (which the stressed-skin wing approaches) is very beautiful so long as it is whole, it becomes a good deal of a nuisance as soon as one has to cut holes in it. It is quite difficult to carry the skin stresses around an opening of any size, and in a multi-cellular wing the problem is aggravated by the fact that any large opening, such as a wheel well for the retracted undercarriage, would cut into several of the spars. Mr. Northrop gave it up and put trousers on his fixed undercarriage; and when he had to carry bombs he hung them under the wing, on the outside, thus completely spoiling a perfectly good aeroplane.

Designers of military aircraft have to think not only of retracting undercarriages, but also of such things as wing tanks, possibly machine guns, and bombs. This fact almost rules out completely any thought of using the multi-spar type of wing structure. Two other alternatives suggest themselves: the single-spar wing and the two-spar arrangement. In each of these two general classes of wing many detail variations are obviously possible.

Round about 1920 German designers began to use single-spar wings on their high-efficiency gliders. These were of





Somewhat similar to the construction of the Empire boat wing is that of the Short-Mayo Mercury. The fuel tank is in the form of a large tube which reinforces the wing, particularly in torsion.

very large span, and it was almost impossible to avoid deflection of the wing spars. In itself this deflection did not matter, provided the angle of incidence did not change along the span. If it did, and wing-warping occurred, the machines would become uncontrollable. By using a single spar and covering the leading edge of the wing as far as the spar, a type of construction could be provided which allowed the wing to bend, but which, owing to the torsional stiffness of the D-section formed by the spar and the ply-covered leading edge, was very stiff in torsion and prevented wing-warping.

Although there seems to be some slight doubt on this point, it is fairly certain that the German designer Willy Messerschmitt was the first to employ the D-section spar-leading edge combination in power-driven aircraft. The Messerschmitt aeroplanes have always been noted for their lightness (in fact, once upon a time they were too light), so presumably the Messerschmitt type of wing construction is efficient. It does, however, suffer to some extent from the same objections as the multi-spar in that objects which have to be stowed inside it have an unpleasant habit of always wanting to go just where the spar is located. It *is* possible to circumvent the difficulty by arranging for some of the stowaways to go in front of the spar, reinforcing the opening in the leading-edge covering, or to go aft of the spar, where there is less room, but where the cutting of openings is of less structural consequence.

Another and no less ingenious scheme which has been used in this country and in Germany is the single tubular metal spar. The late Mr. F. Duncanson designed such a spar. It was first tried out in the Segrave Meteor with good results. Later the scheme was incorporated in a Blackburn commercial aeroplane. The type did not go into production, but that was not due to any shortcomings on the part of the particular type of wing construction.

It is, of course, well known that a member of circular cross-section, in other words a tube, is structurally efficient, i.e., has a favourable disposition of the material, when loaded as a strut, and that when it is subjected to a lateral load, that is to say when it is loaded as a beam, it is less efficient, due to the fact that the material is symmetrically disposed, and thus a fairly large proportion of it is situated near the neutral axis, where it contributes little to the strength. That fact might have been supposed to prove that a tube is not an efficient wing beam. There are, however, other considerations. Torsional stiffness, particularly in a cantilever wing, is more important than plain deflection, and it so happens that the tube is an efficient transmitter of torque.

In order to improve the bending strength of the tubular spar Mr. Duncanson reinforced it top and bottom with corrugated strips, riveted on to the main spar walls. In that way a member efficient both in bending and torsion was produced. The ribs were simply bolted to front and rear walls of the tube, and the wing covering was fabric. Weight was saved by using the inner portion of the spar as the main fuel tank.

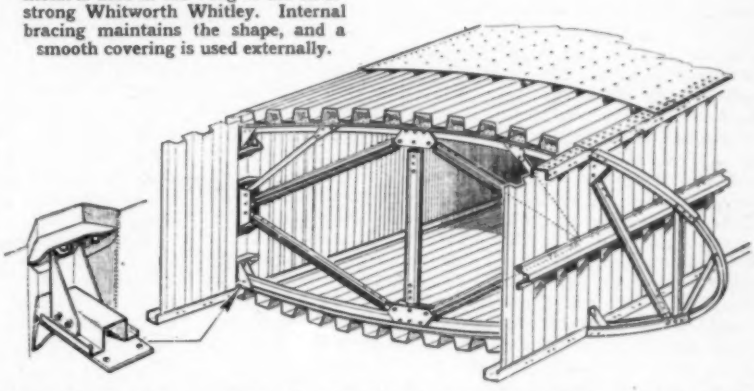
A variation of the Duncanson "theme" is found in *Mercury*, upper component of the Short-Mayo composite aircraft. In this case the tubular spar forms fuel tanks extending almost to the wing tips, but it is used to reinforce and not to supplant the main spars, which have T-section corners and tubular braces. The tubular tank assists the wing considerably in resisting torsion.

One German firm, the Hamburger Flugzeugbau, uses a welded steel tube spar. This makes for very simple construction and has stood the test of time in actual operation over the Atlantic.

One ingenious version of single-spar construction is the Stieger monospar. In this the torsional strength is provided by two spirals of wire or tie-rods running around the wing in opposite directions, the single spar carrying bending loads only.

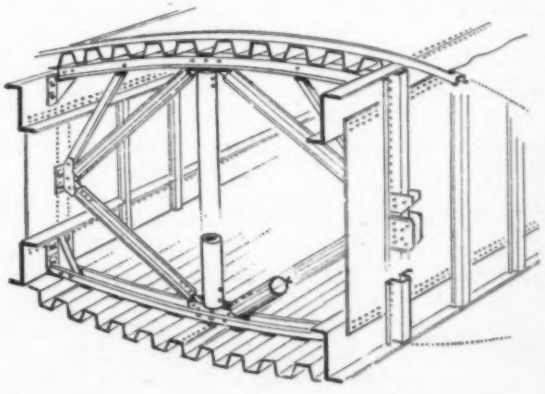
In spite of its simplicity, regarded purely as a structure to carry air loads, the single tubular spar is efficient, but it does present problems similar to those referred to in connection with the Messerschmitt D-section spar. Attachment of engines and military load becomes somewhat difficult and to some extent nullifies the advantages of the single tube.

A complete spar box of corrugated metal is used in the wing of the Armstrong Whitworth Whitley. Internal bracing maintains the shape, and a smooth covering is used externally.

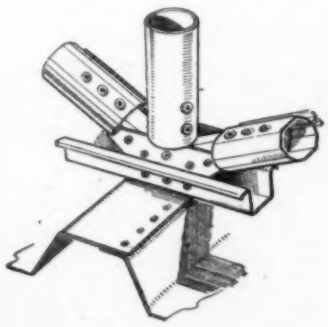


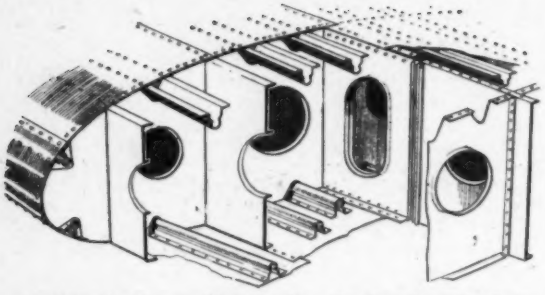
From the foregoing it will be appreciated that when considerations other than purely structural ones are taken into account neither the multi-spar nor the single-spar wing is altogether ideal. That explains why the majority of designers, British designers at any rate, prefer the two-spar construction in one of its many possible variations. These may be divided broadly into two general classes, which may perhaps be defined as the distributed flange and the concentrated flange types.

By the former is meant a type of box spar, in which the walls of the box form the webs of front and rear spars, the top and bottom of the box taking the bending loads.



The wing of the Armstrong Whitworth Ensign is generally similar to that of the Whitley, but the strips in the corners of the spar box are of different section.





An example of a multi-spar wing, the American Northrop. Although good structurally, this type makes installation of tanks and bombs difficult.

Diaphragms or ties inside the box keep the section rectangular, and it is usual to reinforce the corners somewhat where the top and bottom of the box are joined to the walls.

Like the distributed flange, the concentrated flange type of construction may take many forms. Also, it is obvious that it is not confined to the two-spar type of structure. Perhaps one of the clearest examples of what is meant by the expression is the type of structure used in the Short Empire flying boats. The spar "box" is formed by tubular braces in the vertical spanwise plane and ribs in the fore-and-aft direction, covered with sheet metal reinforced by stringers. At the corners of the box section are large extruded T-sections.

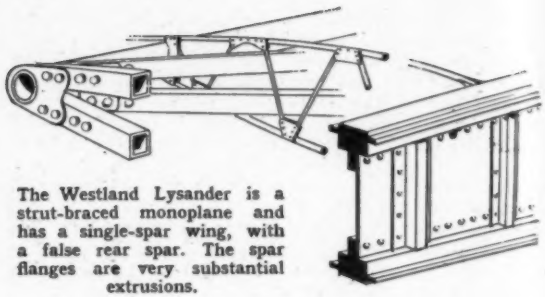
To stiffen the skin covering and to reduce the panel sizes, spanwise stringers are used in most British designs. Sometimes the inner covering of the spar box is corrugated instead of having riveted-on stringers. This is the scheme followed in the wing construction of the Armstrong-Whitworth Ensign and Whitley machines.

Unit Construction

Whatever form the wing construction takes the problem of attaching the sheet covering is always considerable. For the internal structure the position is eased by the fact that the members can be assembled as units while still "get-at-able." With the covering this is not always so, and different forms of riveting have been resorted to in order to facilitate the work. Lately there has been a tendency to develop unit construction to include the wing covering, large panels being made up on jigs and applied as complete units afterwards.

For making the joints in sheet metal, riveting is still the only process used to any extent, although spot welding is being developed and may one day supplant riveting, at any rate for certain classes of work. For aerodynamic reasons it is desirable to have the outer surface quite smooth. This necessitates having the heads of rivets countersunk so as to lie flush with the surrounding metal. As flush-riveting is slightly more expensive, a compromise is frequently made by having only the front third or so of the wing flush-riveted, this being the region of greatest velocity and therefore the most important.

It will be obvious that in a wing totally covered with sheet metal a stage must be reached when it is not possible to get a holding-up tool inside the wing. Where planks are put on *in situ* this means that the last plank has to be secured by special screws. When the unit construction is employed it is usually possible so to arrange matters that free edges are left which are accessible for riveting, although even here a certain amount of bolting or screwing is almost inevitable.



The Westland Lysander is a strut-braced monoplane and has a single-spar wing, with a false rear spar. The spar flanges are very substantial extrusions.

The geodetic type of construction introduced by Mr. Wallis, of Vickers-Armstrongs, is in a class by itself, and lies between stressed-skin construction and the older beam type. The geodetic member which runs diagonally across the wing may be regarded as a sheet-metal covering in which diamond-shaped holes have been cut, leaving behind the geodetic strips. These strips carry the stresses along the surface of the wing. As the Wellesley's structure was described in great detail only about a week ago it is unnecessary to say more of geodetic construction here.

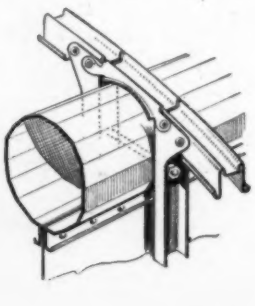
The Light-metal Age

As mentioned in the early part of these notes, steel was used more than light alloys in the days when corrugated strip spars were used in thin biplane wings. With the change-over to the thick cantilever wing of monoplane type came a change in materials; light alloys are now used almost exclusively, except for comparatively few highly stressed fittings, for which steel still holds its own.

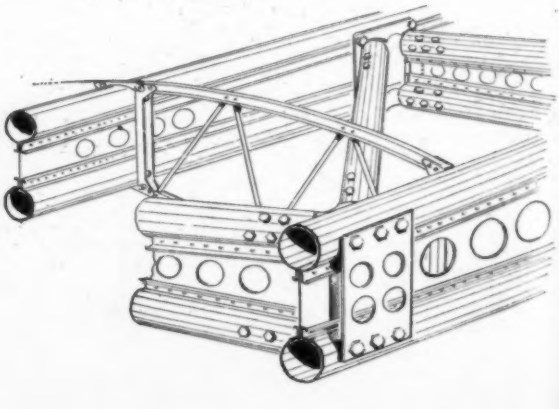
Even in the largest aircraft built at present the covering is of relatively thin gauge. To use steel economically for the covering would mean gauges so thin as to be impracticable. The two materials favoured by aircraft designers for covering and, indeed, for most of the rest of the structure, are duralumin and Alclad. Each has its particular advantages. Duralumin has been in regular use for a longer period of time, but to protect it from corrosion it is necessary to treat the surface anodically. With Alclad this is not always considered necessary, the outer layers of pure aluminium which cover the inner duralumin sheet and form with it the "sandwich" being "self-healing," so that a scratch will grow together and prevent corrosion of the inner material.

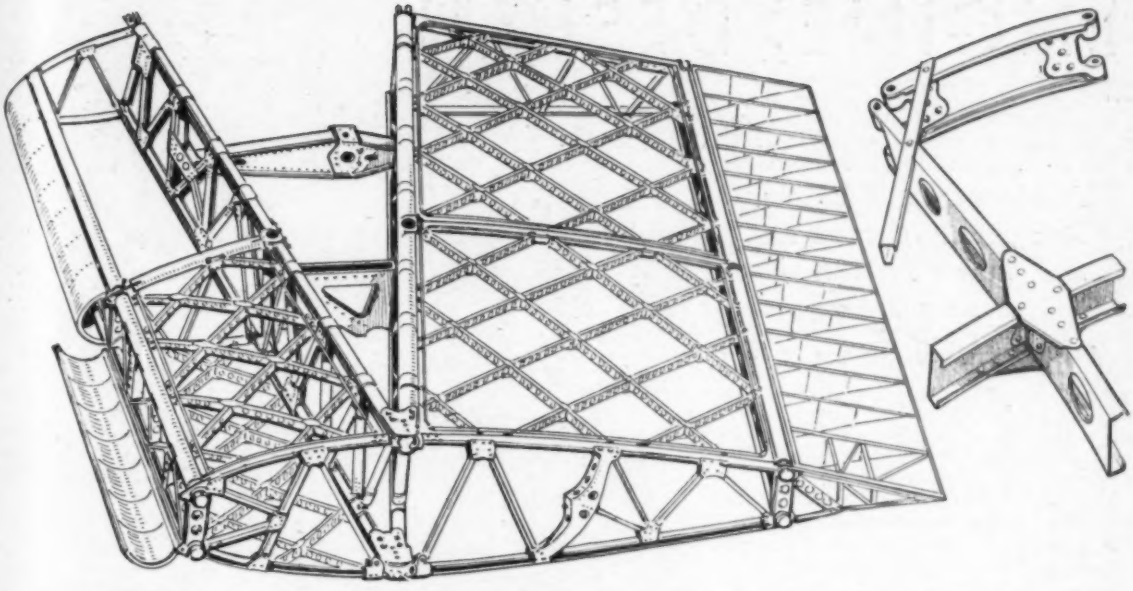
When we come to build really large aircraft there is reason to think that steel may come into more extensive use again. When that happens electric spot welding may replace riveting and possibly save a good deal of time.

Magnesium alloys are not yet used extensively for the primary structure of aircraft. The low specific gravity makes them particularly attractive, as they can be used



Biplane practice has been adapted to the wing of the Hawker Hurricane monoplane. The most unusual feature is the zig-zag drag bracing, which makes the wing very stiff in torsion. The wing covering is fabric wired to the trough in the rib shown in the smaller sketch.





In a class of structure by itself is the Vickers-Wallis geodetic construction. The members run diagonally around the surface, and tension members are made to stabilise compression members, and vice versa.

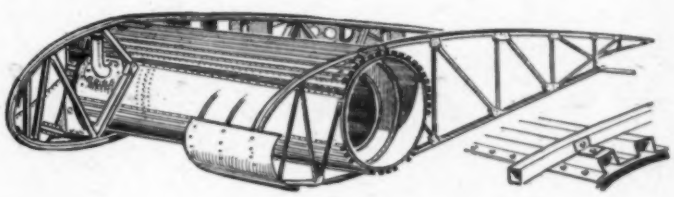
in fairly large bulk, thus possibly avoiding the need for the reinforcement which the heavier aluminium alloys demand. In aero engine work magnesium alloys have found wide application, and their use will undoubtedly spread to the airframe also.

These notes have not covered the subject of wood construction. The reason is that wood construction has been used since the earliest days, and is thus well known. Many excellent aeroplanes have been built of wood, and for certain classes of machine wood is preferable, partly for the ease and rapidity with which a prototype can be built, and partly because it is easier to repair if repairs become necessary away from the factory.

During recent years much development work on improving wood artificially has been done, and good results have been obtained. The improvement is effected by compressing wooden laminations and impregnating them with a synthetic resin. In that way the density of the wood can be controlled, and there is a possibility of proportioning a structural member, such as a wing spar, to the local stresses at any point, thereby avoiding unnecessary weight. For airscrew blades in particular this is a great advantage, as the root portion can be made very dense and given great shear strength, whereas the outer blade portions can be made less dense, so that not only is weight saved but the centrifugal loads are reduced, and the metal hub of the blades can be made lighter. Other applications are now being developed, and promise to come into general use in the near future.

Although plastic materials—that is to say, thermo-setting resins—have been used for parts not very highly stressed, they have not yet reached a stage in their development where they can be used for the primary structure. The work is, however, progressing, and in time we shall probably see fairly large units of an aircraft moulded in plastic materials. Thermo-plastic materials are already being used extensively for such items as windows and windscreens. It might be explained here that with thermo-setting materials the substance becomes inert after heating, and is then impervious to fire, petrol, oil and acids. Thermo-plastic materials, on the other hand, can be formed into any desired shape under pressure with the application of heat. If heated afterwards, they again become plastic.

(*Fuselage construction is dealt with in an article on pages* 552-553.)



A tubular single spar was used in a Blackburn commercial monoplane designed by the late Mr. Duncanson. The compression side of the tube was reinforced by corrugated strips, and the spar also acted as a fuel tank.

Director-General of Production to Visit Scotland

IN reply to a deputation of Scottish M.P.s who called last week to complain that Scotland had not received a fair share of rearmament work from the Air Ministry, Sir Kingsley Wood explained that very substantial orders had already been placed in Scotland as a result of the expansion scheme and that he was very hopeful that it would be possible to make further use of Scottish engineering and industrial resources. In general he was following the policy of taking work where labour was available rather than that of erecting new factories. This policy had the advantage that it spread the benefits of the expansion scheme more widely and produced results more quickly. He was arranging to obtain lists of firms in Scotland which were suitable to undertake sub-contracting work for the air programme, and in so far as this capacity could not be employed on direct sub-contracting work for the aircraft factory at Dumbarton, firms in Scotland would be invited to submit proposals for the manufacture of aircraft components. Mr. Lemon, the Director-General of Production at the Air Ministry, would be visiting Glasgow and Edinburgh very shortly and arrangements would also be made for an exhibition of patterns so that firms in Scotland would be able to see the manufacturing problems involved.

Sir Kingsley also mentioned that in addition to the schools and stations already established in Scotland, further sites were being examined, and a repair depot, to employ some 2,500 men, would be located at Abbotsinch, near Glasgow.

ENGINE DESIGN and MATERIALS

Problems that Face the Aero-Motor Constructor and Some Methods of Solving Them

By D. R. POBJOY, B.Sc.

ENGINE sizes and types were formerly selected by their makers in accordance with their own ideas as to what constituted the best engine. Some makers stuck doggedly to one model, and in course of years developed it to a high pitch of efficiency. Others produced a range of engine sizes in the hopes that one or more would prove popular.

The aircraft designer was thus limited in his choice of power plant and designed his machines accordingly.

The intensive development taking place to-day both in military and commercial aircraft has compelled a change in this policy. New designs of engines are being produced to meet the specified requirements of the aircraft designer.

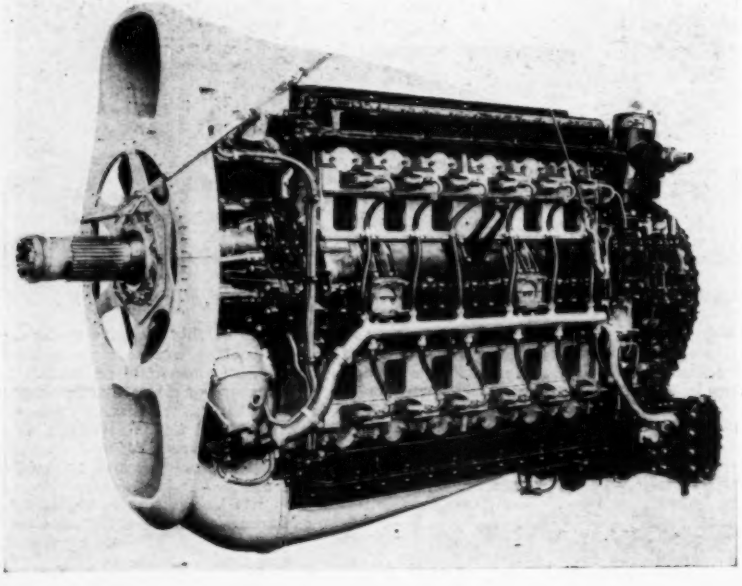
A notable aspect of this trend is the concentration on higher and ever higher engine powers to figures scarcely considered practicable a few years ago. The demand for speed combined with carrying capacity can only be met by still larger and more powerful machines. Concerning commercial aircraft, a study of the economics of airline operation clearly indicates that the financial success of commercial aviation is bound up with the use of large-capacity, long-range, high-speed machines. Ever larger or rather more powerful engines are thus required by the operators of commercial airlines.

An example of a modern ducted cooling installation—one of the Rolls-Royce Merlin engines in an Armstrong-Whitworth Whitley IV.

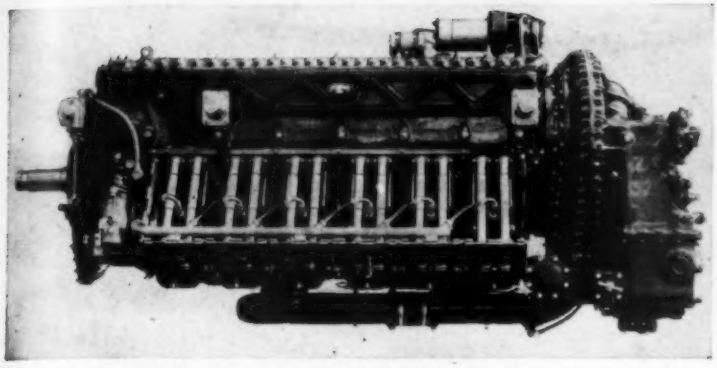
At the other end of the scale efforts, both private and official, to popularise flying tuition among the general public are encouraging the production of tiny engines of much smaller powers than hitherto considered sufficient for the smallest practicable training aeroplane. For many years such machines have been powered with four-in-line engines of 130 h.p. This type of training engine was developed in England, and its layout has since been followed all over the world.

A crop of similar but smaller engines, and also flat-twin variants, ranging from 30 to 100 h.p., has recently made its appearance. It remains to be seen whether the saving in first cost of the very small engines will effect the hoped-for economies in purchase price, operating and maintenance costs of the complete aircraft.

One striking feature of these divergent trends is the comparative neglect of the medium-powered engine. A notable exception is the 375 h.p. unit used in large numbers by the R.A.F. in twin-engined training machines. No doubt there will be a recrudescence of interest in this and somewhat larger powers for commercial feeder-line aircraft, when the not inconsiderable number of machines



"An interesting arrangement is the H-type. . . . There are a good many more advantages in this design than at first meet the eye": the 24-cylinder Napier Dagger VII.



A fine example of air-cooled vee-twelve practice : The De Havilland Gipsy Twelve.

of this type at present in existence are due for replacement by more up-to-date types.

Until comparatively recently, for engines of medium to large powers, the world-wide choice of layout was restricted to water-cooled vee-twelves and single-bank radials usually of nine cylinders—always excepting the famous British two-bank fourteen-cylinder engine that was for fifteen years the sole example of the now popular two-row radial.

The vee-twelve was heavier than the radial, but had much less frontal area. With the advent of the high-speed, cleaned-up aeroplane, the drag of the engine unit became of greater importance. In succession the Townend ring, the NACA cowling, and the fully baffled modern long-chord cowl made their appearance on behalf of the radials, and finally, in order to obtain higher powers without increase in diameter, the modern two-bank radials. In many cases the stroke of the engines has been reduced and the speed put up, resulting in increased ratings accompanied by a reduction in diameter.

The radial engine is necessarily inherently lighter for a given swept volume than any other form, owing to the smallness of the crankcase and the shortness of the crankshaft. The ratio of maximum to mean torque in the latter is also smaller than in other types. Nevertheless, in modern fully equipped engines the difference in weight of the various types is not so pronounced as formerly. The crankshaft and crankcase are, after all, only a small proportion of the entire engine. The weights of the v.p. airscrew, the reduction gear, supercharger, auxiliary gear box, and accessories generally, as well as the cylinders themselves, are more or less independent of the engine arrangement. Coupled with the fact that for equal big-end durability the in-line or vee engine (i.e., engines having not more than two rods per crank) may be run faster than the radial, the difference in the weight per horse-power is approaching vanishing point.

To take advantage of this permissible greater speed, the in-line engine must not have its speed limited by its valve gear. Overhead camshafts are, therefore, desirable in this type of engine. The structure of this gear, as distinct from its reciprocating parts, is, however, inclined to be heavy.

A well-known British manufacturer, in the endeavour to put up the speed of radial engines, built a two-bank radial with overhead camshafts. The increased weight of the gear nullified, however, any gain in power per lb. of engine or per unit frontal area.

Confronted with the limitations of push-rod operation and of the exhaust valve itself at high m.e.p., this maker tackled the biggest innovation in twenty years and produced, after a tremendous amount of intense research work, a series of high-powered radial engines having single-sleeve valves, with the successful results now known and admired the world over.

Besides overcoming the difficulties of valve operation in radials and short-circuiting the exhaust valve, the sleeve-valve engine has proved itself to possess many additional merits likely to have far-reaching effect on engine design in the future. Among these merits are:—

(1) No valve maintenance necessary, or, indeed, possible.

(2) The durability of the valve gear is in step with that of the other components of the engine.

(3) Owing to the movement of the sleeve, the oil film on the piston and rings is not so liable to be impaired at the top and bottom of the piston travel as in engines with fixed liners.

(4) A higher ratio of compression may be used with a given fuel, resulting in improved fuel economy, and reduction of exhaust noise and temperature.

(5) Large port areas positively controlled at high speeds without springs, permitting high power outputs per unit of swept volume.

In the meantime, air-cooled vee-twelve engines made their appearance, while the water-cooling exponents introduced evaporative, pressure, and glycol cooling with the object of reducing the size, weight, and drag of the radiators. "Duct" cooling of water and oil radiators appeared, by which it is theoretically possible to reduce the cooling drag to vanishing point.

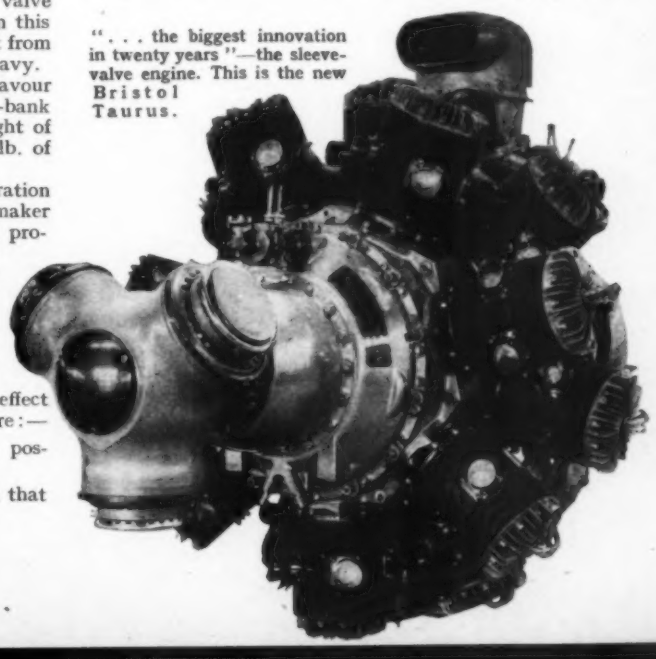
In the search for a compromise between the sharp-nosed but heavy in-line engine and the blunt but light radial, and in order to avoid increasing the piston diameters and consequently reducing rotational speeds for large powers, many other cylinder arrangements have been reviewed.

A *Compact Design*

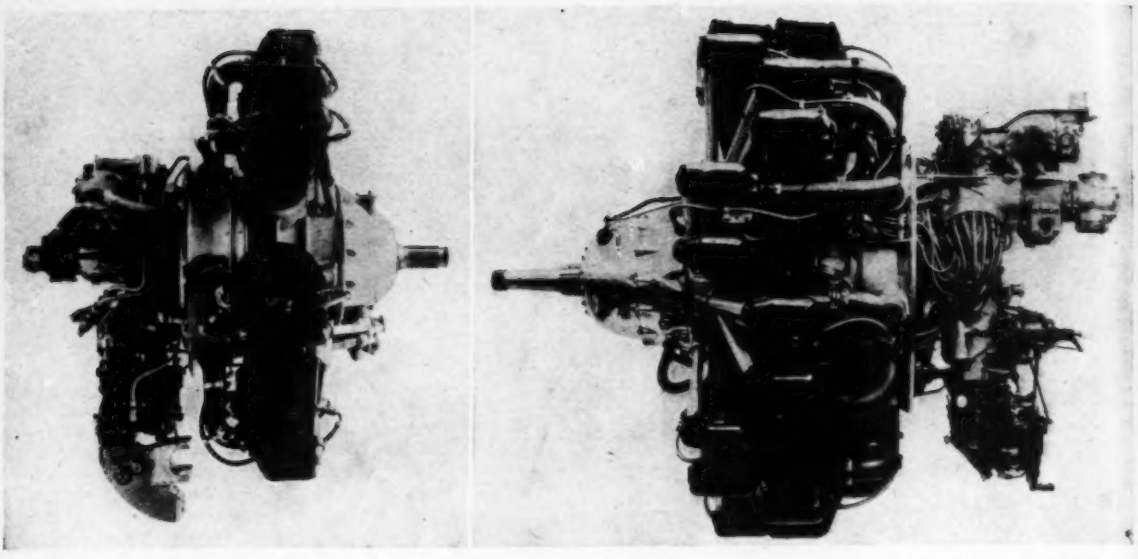
At first sight a multi-bank radial having, say, four banks each of seven cylinders driving a four-throw crankshaft, with an overhead camshaft over each row of four cylinders, would appear to be the most compact engine possible and capable of running at high speeds. The design of the crankshaft, its bearings, and the crankcase, not to mention supporting the engine, present some difficulty. The seven overhead camshafts would also render the engine complicated to assemble and expensive to make. Several such designs have been prepared, but no one has yet had the temerity to announce their manufacture.

An interesting arrangement which overcomes some of the difficulties (although heavier than the multi-bank radial) is the H-type engine, once more a British innovation. Originally a sixteen-cylinder push-rod engine, the latest type now used in the R.A.F. is, in effect, two flat-twelve engines arranged vertically on a common crankcase and driving a single reduction gear.

There are a good many more advantages in this design than at first meet the eye. The individual pistons are small, there is no difficulty in big-end construction, and overhead camshafts are conveniently arranged. Moreover, the gear-wheel end of the airscrew-shaft is largely relieved



"... the biggest innovation in twenty years"—the sleeve-valve engine. This is the new Bristol Taurus.



(Left) "... the 375 h.p. engine used in large numbers by the R.A.F. in twin-engined training machines." The engine is the Armstrong Siddeley Cheetah X. (Right) The same makers were the first to tackle seriously the production of the two-row radial. The Tiger IX is seen here.

of side thrust. The engine can, therefore, safely run at remarkably high speeds. The example in question develops 1,000 h.p. at 4,200 r.p.m. from a capacity of only 16.8 litres.

To remove the last jot of power-plant external drag, it will, no doubt, some day be necessary to bury the engines in the wings. The flat-twelve may then come into its own. At present, beyond an occasional patent specification, there is little sign of its materialisation.

All modern military aircraft engines (except for training purposes) are provided with superchargers partly to maintain power at altitude and partly to provide a temporary excess of power at will such as during take-off. A gear-driven supercharger arranged to provide ground-level atmospheric pressure in the induction system at great heights will supply more mixture pressure at ground level than can be safely used even for the heaviest take-off boost. The hand-operated override on the automatic boost control must be arranged so that even during take-off the intake to the supercharger is partially throttled. In these circumstances some power is wasted in the blower, but more serious is the unnecessary heating of the charge, which seriously limits the permissible power of the engine. This difficulty has been overcome by the introduction of the two-speed supercharger, the lower ratio being selected to permit full-throttle operation during the period of take-off.

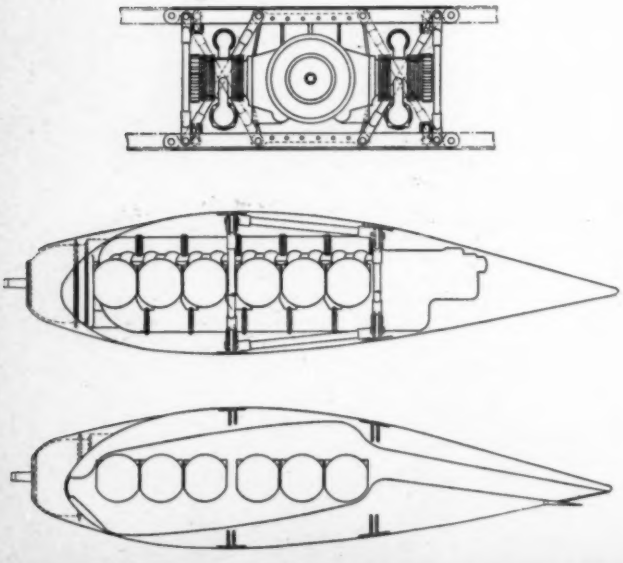
Even so, the charge becomes much hotter than desirable. More take-off power could be used if the mixture could be cooled before it reaches the cylinders. Unfortunately, such "intercooling" devices are cumbersome, and in the case of radial engines spoil the compactness of the layout. To facilitate cooling the charge, two-stage blowers with a cooler between the stages are being considered as a solution.

If optimum performance is required at all heights, the driving gear ought perhaps to be infinitely variable between the upper and lower speeds. Already one foreign engine has a three-speed gear. These multi-speed gears are in some cases of the layshaft type, others have an epicyclic arrangement. Usually the change-speed mechanism is operated by hydraulic pistons fed from the engine oil system. An attractive alternative now under development is the use of electro-magnetic clutches.

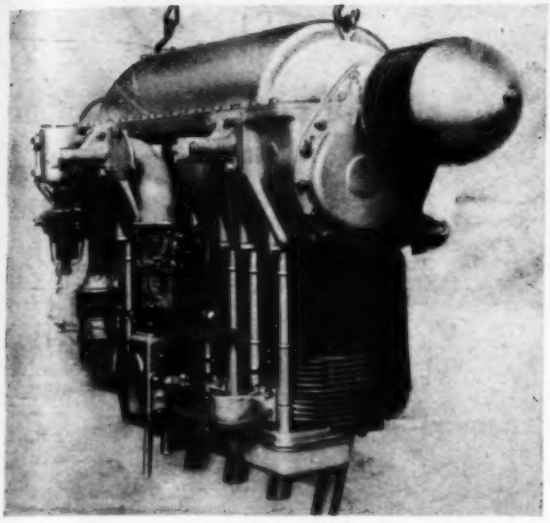
Turbo-blowers

The speed of the blower can be automatically regulated by driving it with an exhaust-driven turbine. This system has the additional advantage of using some of the energy otherwise wasted in the exhaust. In effect, the engine is "compounded," as in steam-engine practice, except that the low-pressure power output is not connected to the main crankshaft but performs the first-stage compression of the charge. This system has been used for many years in experimental aircraft, but its defects have hitherto prevented its general adoption.

The drawbacks of the system are chiefly the necessity of making the exhaust piping flexible yet gas-tight, and the inevitable slight back pressure on the engine exhaust valves. The latter is particularly serious near the ground, but of little importance at really great altitudes. With the improved materials now available, and particularly in view of the reduced sensitiveness to back pressure of the sleeve valve, the system is now receiving fresh attention to meet the demand for "stratosphere" flying. It has been proposed to provide the engine with a built-in, gear-driven blower capable of providing adequate take-off boost and a turbo-compressor in series to maintain power up to great



"It will no doubt, some day, be necessary to bury the engines in the wing. The flat twelve may then come into its own." Here is a recent Bristol patent.



Two contrasting types of under-100 h.p. engines. Above is the 90 h.p. Cirrus Minor, and on the right is the author's own well-tried design, the 95 h.p. Pobjoy Niagara III.

heights. An intercooler would be provided between the two stages.

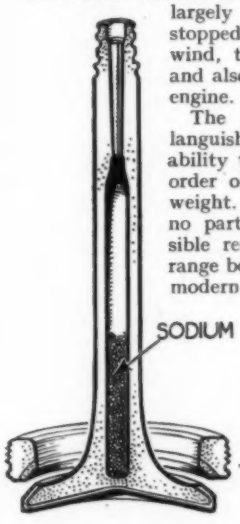
The speed ranges of modern aircraft demand in most cases the use of a variable-pitch airscrew, usually the constant-speed type with manual adjustment of the governed speed. The two-fold advantage follows that the airscrew pitch is reduced, giving an efficient angle of incidence during take-off and climb, while the engine is permitted to turn at its rated or even maximum speed under those conditions.

Alternatives

With extremely wide speed ranges the selection of the best pitch during take-off may allow the engine under full permissible ground boost to exceed its maximum permissible speed. This condition may be met by expansible airscrew blades, a two-speed gear drive, or by designing the engine to stand a temporary overload of speed as well as of power.

The first of these proposals seems hopeless, the second has often been proposed, but no practical form has yet appeared; the third seems simplest, and is already met to some extent for military aircraft by the power-dive requirements.

The recent refinement of full-feathering provision is largely to allow a "dead" engine to be stopped with its blades edge on to the wind, thus saving a good deal of drag and also further damage to the defective engine.



A sodium-cooled valve in section, seen with a stellited seat.

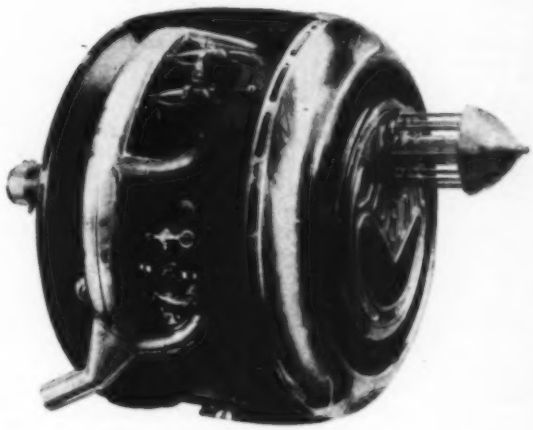
The compression-ignition engine has languished of late years owing to its inability to provide take-off powers of the order of the petrol engine of the same weight. Moreover, for military use it has no particular advantages except a possible reduction in fuel weight for long-range bombers. The fuel economy of the modern high-compression, spark-ignited engine using fuel of 100 or higher octane value now approaches that of the C.I. engine.

Nevertheless, for large civil aircraft the C.I. engine has several desirable features. A good deal of quiet research work is going on, and sufficient data are now available to indicate that, given the will and the money, most large air liners in a few years' time might well be powered with C.I. engines.

Engine-cooling arrangements and, indeed, installation generally, are now no longer simply the outcome of war between the engine and aircraft people, but have been subjected to a great deal of scientific investigation. Calculated minimum quantities of cooling air are now provided, with the least possible disturbance at the exit. Cooling systems are slowly but perceptibly moving toward the ideal proposed some years ago by the R.A.E., Farnborough, of the buried, close-baffled engine, an air inlet at any desired location of high pressure, an air tunnel around the engine conducting the engine exhaust as well as the heated air, to an exit near the wing trailing edge, where a flap may control the flow through the system. For really fast machines it can be shown theoretically that the heat energy imparted to the stream may not only cancel out the cooling drag but may actually impart a gentle push!

Materials

No new general-purpose alloy steels have appeared recently, although the standard of cleanliness and uniformity of existing steels has improved. The more general



use of X-ray examination and improved forms of magnetic crack detectors has reduced the chance of defective parts getting into service. Super-high tensile steels, i.e., those having an ultimate tensile strength between 120 and 150 tons/sq. in. have not yet emerged from the laboratory stage.

Special steels responding to nitrogen hardening are now available in various grades suitable for crankshafts, cylinders and hardened pins. The earlier forms of nitriding steels contained a little aluminium. The hardened case was liable to be patchy and the core to vary in strength. The modern nitriding steels are of the chrome molybdenum type and possess very good all-round qualities.

High-nickel high-chromium austenitic steel is now almost universally used for exhaust valves. Fortunately, this material lends itself to nitriding of the valve stems.

Manganese nickel chrome steel, having almost the same expansion coefficient as aluminium, is largely used for valve seat inserts. In some cases exhaust valve steel is used, as although its expansion coefficient is not quite as high as that of M.N.C. its resistance to hot corrosion is somewhat better.

Aluminium and magnesium alloys, both for casting and forging, continue to improve. The latest forging alloy RR.77 has the highest strength/weight ratio of any known structural material.

Heat treatment of the cast magnesium alloys has been developed, greatly improving their fatigue strength. The latest forged magnesium alloys have nearly as good a

strength/weight ratio as the best aluminium alloys, while being of only two-thirds the weight. Where rigidity is of importance the extra bulk of the magnesium alloy is of advantage, a notable application being for airscrew blades. Unfortunately, the elastic moduli of the light alloys and of steel are roughly in proportion to their density. The ideal of a light alloy with the strength of high-tensile steel and also having its elastic modulus is probably a physical impossibility.

Engine Details

Crankcases for line engines are cast in high-tensile aluminium or magnesium alloy. Radial crankcases are usually machined all over from aluminium alloy forgings.

Cylinders are machined from steel forgings and almost invariably nitrided in the bore.

Pistons for high-powered engines are machined all over from aluminium alloy forgings, and are of the full-skirted type with a scraper ring at the bottom. The oil circulation through the big-end bearings of modern line and radial engines must be so high to keep the bearings cool that the slipper type of piston can scarcely cope with it. Moreover, it is rather simpler to machine a full-skirted piston all over than a slipper type. Some pistons have ribs under the head and also round the inside of the skirt to increase the effectiveness of the oil as a cooling medium; this, however, necessitates larger coolers for the oil itself.

Piston Rings have developed rapidly of late. Fractures in service have been reduced by abolishing "hammering" in favour of "heat-forming." "Feathering" and wear have been reduced by the use of improved materials, such as chromium irons. Ring sticking has been practically eliminated by the introduction of the taper-sided ring. Damage to the ring during its early life has been reduced by the new etched oil-holding finish provided on the face.

Exhaust Valves are invariably of the hollow sodium-filled type, made of austenitic high-nickel, high-chromium steel, nitrided on the stems and stellited on the tips and seats. The insert seat is usually stellited as well. The function of the stellite is not so much to give hardness as to prevent corrosion and erosion of the seatings by the products of combustion, particularly when running on weak mixtures and with leaded fuels. The whole surface of the valve head is in some cases protected by welding on a thin layer of a special nickel-chromium alloy.

Sparking Plugs have recently received a fresh lease of life in spite of higher m.e.p.'s and lead attack by two successful innovations, a plurality of fine platino-iridium earth wires and the substitution for mica in the insulator of sintered aluminium oxide, known as Sintercorund.

Magnetos have been reduced in weight and increased in efficiency by the use of rotating magnets made of the new magnet steel containing alumium. Metallic braided cable systems are being replaced by substantial metal conduits or harness.

Crankshafts are usually of chrome molybdenum steel with nitrided crankpins and journals. The "floating kidney" type of loose balance weight popular in American radials does not seem to have found favour in this country. A similar improvement in smoothness could be achieved by a considerable increase in the flywheel mass of the shaft with, however, an increase in the weight of the engine and a danger of lowering the torsional resonance of the shaft into the running range. As speeds of rotation go up the device becomes of less value.

Lubrication systems usually include a means of supplying extra oil to the cylinders and connecting-rods while the oil is still cold, to permit take-off shortly after starting.

Plain Bearings, whether floating or split, are invariably of the steel-backed type lined with anti-friction metal. Copper-lead lining has a much greater fatigue strength than white-metal, but is more susceptible to scoring. A copious supply of well-filtered oil and a large oil cooler are necessary with the former material.

Highly developed white-metals of grades varied to suit the particular conditions are, however, available, and except when the bearing pressures are very high may show an advantage over copper-lead.

Cadmium-nickel-indium linings are superior to white-metal as regards strength and to copper-lead for resistance to scoring.

Pure silver has been found experimentally to have by far the greatest fatigue strength of any known lining metal. Its frictional qualities are, however, rather erratic. Certain difficulties overcome, the aircraft of the future as well as the clouds may have silver linings!

UNDER-SECRETARY on BRITAIN'S AIRWAYS

SPEAKING at a dinner of the Women's Advertising Club held in London on Tuesday of last week, Capt. Harold Balfour, Under-Secretary of State for Air, gave his audience a finely presented review of the outstanding aspects of past, present and future aviation.

Starting by comparing the debit and credit sides of aeronautics, Capt. Balfour spoke of the advantages of speed in the carriage of passengers and mails, then proceeded to set off against these facts the menace of the bomber, upon which countries like our own, only desiring peace, were having to rely for their counter-offensive against any potential enemy who tried to exercise this dreadful weapon against our cities. He submitted that if we took the narrowest point of view—that of the immediate moment—a world vote would abolish the aeroplane. But he believed that his audience would agree with him in rejecting the idea of drawing a conclusion on the narrow compromise of the immediate present and would turn rather to what civil aviation was likely to accomplish in the future, at the same time believing and hoping that the present madness of the world race in armaments would draw to a finish.

Capt. Balfour went on to review the pioneer flights from which our Empire civil aviation originated, and spoke of the technical advancement in aircraft since those days. Unfortunately, even this progress had not been such as to make civil aviation a paying proposition. Commercial flying had more and more tended to become a political instrument whereby the various nations of the world penetrated with their economic and political interests into the territories of others, irrespective of the commercial value of new lines and extensions to old ones, and at a heavy cost to the citizens of the different countries, who had to foot the bill by subsidies.

In this country we had recently, on the recommendations of the Cadman Committee, increased our subsidy from 1½ to 3 million pounds; we could not afford to be left behind in this rapid process of development. If we were to compete with French, Dutch and Italian lines to the east—all of which enjoyed a subsidy considerably greater than that paid to our Empire lines running along parallel routes—then we must accept this subsidy need until aeronautical science had developed to the stage when revenue was likely to balance operational costs.

Capt. Balfour went on to review in detail the comparative advantages of large landplanes and flying boats, and touched on the safety of each type, saying that in the case of a four-engined aircraft of either kind there was no real difference in risk. He then proceeded to review the all-up Empire mail scheme. The scheme envisaged four or five services a week to India, three to Malaya and East Africa and two each to South Africa and Australia. When it was in full operation a passenger would be able to fly in just over two days to India, two and a half to Malaya, four to South Africa and seven days to Australia.

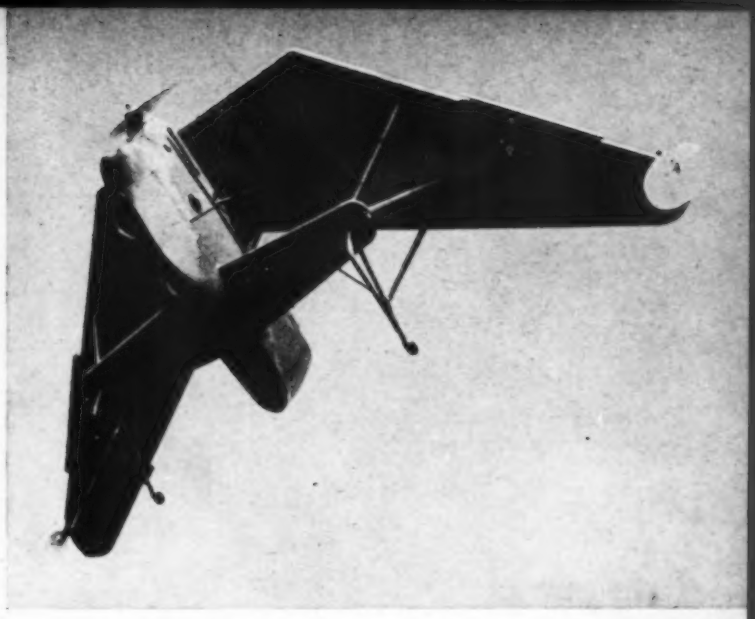
The speaker reviewed transatlantic service possibilities, discussing various methods of operating with heavy payloads, such as more powerful engines, high-lift devices, boundary layer control, aerial refuelling, catapulting and composite aircraft.

"The application of the improvements which I know we shall see in the next few years," said Capt. Balfour, "will mean London to Cairo non-stop, and a second stop at Karachi, this at speeds of probably three or four hundred miles an hour; then there will be a weekly or bi-weekly special service from London—first stop Delhi, second stop Singapore, third stop Australia. I believe there will be regular non-stop trips from England to the Cape, while the North and South Atlantic crossings will be just ordinary daily flights."

Another speaker at the dinner was Sir Arthur Street, First Deputy Under-Secretary of State for Air, who made some amusing remarks. Miss Audrey Deans, president of the Women's Advertising Club, was in the chair.

CONTROL PROBLEMS DISCUSSED

A Summary of Prof. G. T. R. Hill's R.Ae.S. Paper : Finding Out What is Wanted : Recent Developments



"Flight" photographs.

Prof. Hill with the Westland-Hill Pterodactyl Mark V—the last of the series of tailless types designed by him and intended in this case as a two-seater fighter. Earlier examples were in the light category. Pterodactyl V is seen flying in the photograph above.

IT was to be expected that, as chairman of the Stability and Control Sub-Committee of the Aeronautical Research Committee, Professor G. T. R. Hill, M.C., should have some interesting statements and suggestions to make in his paper on flying controls which he read before the Royal Aeronauical Society on December 1. Furthermore, Prof. Hill has a reputation both as a speaker and a demonstrator, and his extracts from the printed paper, which is summarised below, called forth a very reasonably useful discussion—which does not always follow R.Ae.S. papers, however erudite and important.

The fact that Prof. Hill, too, is a pilot of experience added considerably to the interest in his remarks, which were visually illustrated by bicycles, bull's-eyes and birthday cakes. He used the bicycle (ridden in from "off stage") to demonstrate the variation of control requirements at different speeds, and a bull's-eye (on the drawing-board) to keep his listeners reminded of the target of control "goodness" which had to be aimed at. The "birthday cake" was, in fact, a model demonstration of the different pressures experienced around the tail in the slipstreams of twin-engined machines. In addition, and with the help of his brother Air Cdre. Roderic Hill, he demonstrated different degrees of co-ordination by means of a special apparatus at the back of the hall. It was all very refreshing, and yet not too light hearted to be taken seriously.

In his introduction Prof. Hill made it quite clear that the opinions and speculations were entirely his own and did not necessarily express the official view of the Aeronautical Research Committee. He divided his paper into three parts, the first being a general study of the problems of control; the second being devoted to those involved in maintenance of trim; and the third briefly covering some of the more recent developments in control methods.

During his introductory remarks he showed a slide on the screen which illustrated the way in which wing loading has increased more or less in unison with speed; the jumps during the war years, and, more pronouncedly, since the development of v.p. airscrews and flaps, were educative. He stressed the particular need nowadays for better control. Dealing first with the relation of control to stability Prof. Hill said that aeroplanes were normally neither very stable nor unstable in the ordinary way, but both these conditions could apply at and near the stall with violent unstability in roll immediately before, and great stability at times after, the spin had actually started. At present, therefore, most attention was being directed to the improvement of stability at and near the stall, particularly as it seemed probable that in the near future the Service pilot might not have sufficient physical strength to recover from a spin with a high-speed and highly loaded machine.

Pilots' Opinions

Experiments had been made by the R.A.E. with the object of discovering what measure of agreement existed among the pilots when they used the expression "harmony of controls." Though some doubted whether any valuable results would emerge from such tests, it was a fact that certain machines were universally popular—which suggested that there was at least a fairly general idea among pilots of what was actually wanted. Special equipment was now being developed at the R.A.E. to introduce a greater degree of reliability into the experiments. Already the Sub-Committee of the A.R.C. had drawn up a questionnaire which had been sent to civil, test and Service pilots, asking for opinions. The answers showed that it was almost unanimously agreed that there should be a slight increase of necessary control force with speed; but opinion was divided on the point of whether this force should vary with the size of the machine, and the majority preferred a small progressive increase of force during displacement in any axis. It was unanimously agreed that an aeroplane, particularly a large one, should fly by itself, though some pilots were ready to accept, on small types, neutral stability.

It was agreed, too, that all control lag should be avoided and that there should be no trim changes after throttle or flap operation, though in the last case it was suggested that the trim might be permitted to alter slightly to allow for the changed flaps-down characteristics. It was very desirable that there should be no change of trim due to ground interference while landing.

Opinion was divided about the importance of the different controls, though in the newer types there was a tendency to regard the ailerons as being the most important. Needless to say, flaps were universally admitted to be necessary for all new types, and a quickly operable flap was enthusiastically commended by those who had tried it. A number of pilots recommended that the ground angle should be less than the stalling angle, and that the elevator control should not be sufficiently powerful to pull the machine up to the stall after a premature landing.

D

"Flight" photograph.

An example of the flying full-scale model, which was mentioned in a lecture as being a necessity for present-day design assistance. The Short Scion Senior acted as "model" for the Short Empire boat and Sunderland.

Such general opinions as those expressed by these various pilots should, Prof Hill considered, be replaced by accurate quantitative measurements. The difficulty was to know what measurements to make, and how to turn them into a form which would be simple and useful enough for comparative purposes.

The lecturer then described the attempts which were made twenty years ago to measure control in R.E.8s and similar types. It was from the United States that the first really quantitative specification of control and stability had come. Prof. E. P. Warner had devised an elaborate scheme of values for application to large machines. Unfortunately, it was a good deal easier to lay down a specification for a large machine than for a small type about which each pilot usually had special ideas. At this point the whole problem entered the realm of psychology.

Prof. Hill described control as being of three distinct kinds—of position, velocity or acceleration. Ease of operation was lost when a control possessed a mixed function—such as in the case of the throttle control, which first gave forward acceleration and was ultimately used to govern the rate of climb. It was this changing in control function which so troubled the learner. Although it might be said that nothing could be done in practice to prevent this change of function, an analysis of these functions might eventually throw new light on a number of points.

Dealing with control lag, Prof. Hill said that the defect might be caused either by sheer inertia, or by the failure of the airflow to build up to the new pattern required when the control surface position was modified. Control lag was probably the most important cause of over-controlling and consequently of oscillation.

Stability Problems

During the reaction experiments it was taken for granted that the control movements were started with zero force in steady flight, and this brought in the question of trim. In the early days theory and practice tended to get out of step in that, though the machine might be designed to be perfectly stable, the rotating slipstream caused it to exhibit a strong turning tendency. This sort of difficulty had been accentuated with the use of higher powers and of flaps.

The means for avoiding change in longitudinal trim were quite simple So far as throttle changes were concerned the tailplane was the source of most of the trouble. At the N.P.L. some interesting model work was now in progress with the object of studying the slipstream form of a typical twin-engined machine. The irregular "shape" of the slipstream made generalisation difficult and it was to be expected that full-scale machines would often behave unexpectedly. The large pitching effects produced by the use of flaps were opposite in direction, and it was possible to achieve a zero change in trim. When the flaps were lowered the c.p. moved backwards, giving the nose a downward moment, but on account of the additional lift there was an increase in downwash, which caused the nose to rise. The sudden use of engine when the flaps were down might produce a large and uncontrollable nose-up pitching moment, but this trouble could be avoided by the use of a quickly operable type of flap.

The increasing use of the low-wing monoplane had brought a new difficulty—that in which the landing process was affected by the flattening out of the downwash behind the wing. There did not seem to be any obvious means of avoiding this ground effect, though the use of a tricycle undercarriage would remove most of the difficulty.

The problem of balancing control surfaces was becoming increasingly difficult as size, speeds and loadings went up. A geared tab was commonly used nowadays, but this could only be applied to an already well-balanced control surface. Prof. Hill mentioned that Mr. Irving had recently carried out some promising control balance experiments at the N.P.L. It was possible so to design the form of balance that the reduction in stability between "controls fixed" and "controls free" conditions was avoided. An improvement had been noticed with horn-balanced rudders in the old days, and the same principle was now being used experimentally in the design of elevators. An unbalanced elevator tended with controls free to trail at a slight negative angle and this fact explained how control-free stability was normally worse. With Mr. Irving's method of balance, using an unshielded horn, the elevator tended to trail at a positive angle, thus giving the tail greater lift and producing better stability. There was no need to overbalance the elevator to obtain this effect.

Referring to flaps, Prof. Hill said that it was obvious that a powerful air brake made an approach easier, though it introduced new dangers—notably during the flattening-out process, since the machine lost speed very rapidly. He suggested that to combine the advantages of an easy approach and an easy landing, the quickly operable flap was of great value. The present method of motoring in with the flaps down had certain drawbacks and the quick-action flap would remove the necessity for such tactics. In this connection he mentioned Mr. Irving's aerodynamically balanced double flap, which had been fitted to a Miles Falcon. Mr. W. E. Gray, too, had designed an ingenious modification for the Irving flap.

Some means of balance were obviously necessary for flaps which had to be rotated through such a wide angle. In the quick-acting type it would be necessary to provide some sort of gate or stop which would prevent the flap from being raised beyond the position of maximum lift.

Ailerons were not, the lecturer thought, an ideal form of control; they generated yawing moments at low speeds, tended towards flutter and twisted the wing under heavy loads. The most promising form of alternative was an interceptor on the top of the wing, though difficulties had been experienced in the experiments—notably in the lag which had been characteristic of those interceptors so far fitted. Investigations were continuing, but success could not be said to be in sight.

Prof. Hill suggested that control layouts might be simplified.

"Flight" photograph.

Two-control in practice. Inside the cabin of the Stearman-Hammond, in which the wheel is used for steering both on the ground and in the air, through the medium, respectively, of the nose wheel and the ailerons. The machine has no movable rudders.

"*Flight*" photograph.

An R.E.8, shown here in Service form, was used by the Royal Aircraft establishment for early experiments in the measurement of control forces.

A machine equipped with quickly operable flaps and a tricycle undercarriage did not need controls which would do more than normal manœuvres. He mentioned the two-seater machine designed by Mr. Weick and built by the General Engineering and Research Corporation of Washington, D.C., in which the three controls were retained but the ailerons and rudder were were interconnected in a certain ratio and controlled by means of a wheel. This wheel was also used to steer the machine on the ground [*vide* "Indicator's" article in *Flight* of December 1]. It was interesting to note, he added, that the two-control systems appeared to give a "smoother ride" than the standard three-control system.

In order to enable designers to produce a machine which would not require expensive modifications, Prof. Hill believed that the part-scale flying model was now necessary. Already Shorts had achieved splendid results from the use of the Scion Senior as a test model for the Empire boats and Sunderlands. An examination had been made of the relations between model and full-scale aerodynamic characteristics, and the differences could be calculated into the final design.

In conclusion, Prof. Hill believed that the research work now in progress would have good results, and was certainly an improvement on the hit-or-miss methods previously used.

THE DISCUSSION

WITH so much of interest to discuss, and such a comparatively small space of time available, Dr. H. Roxbee Cox, the chairman, called at once on MR. H. L. STEVENS to make a start. The latter impressed the importance of making accurate measurements of control forces, but he felt that it was necessary to know *why* these measurements were being taken. So often a mass of figures was obtained which merely added to the already large amount of undigested knowledge which was waiting for application. He thought that the flaps-down rumble approach was a bad technique simply because the approach was necessarily being made low down and often in an area where obstructions abounded. He wondered whether irreversible controls might not, after all, be a good thing.

AIR COMMODORE RODERIC HILL stressed the importance of having adequate control to stop or reverse motion in the rolling axis, where acceleration forces were violent, and described an occasion when he had rolled a twin-engined machine by throttling back one engine or the other. His detailed memory of the *Hunting of the Snark* provided the necessary light interlude, and he finally remarked that control problems should be unsnarked slowly and carefully.

PROF. MELVILL JONES also agreed that the time had come to make an accurate study of control forces, and the demand for such study was increasing. He complained of the mass production both of machines and of pilots. In the first case the designers were robbed of the advantages obtained from prototype experiments, and in the second case he felt that control forces and reactions should be standardised for the benefit of the pilots, who must necessarily come out of much the same mould.

LT. CDR. R. R. GRAHAM described how a study of bird flight showed that turns were made by twisting the entire wing and not by a flexing of the trailing edge, and complained that present-day machines were by no means as handy in the air as older types.

CAPT. W. A. M. BOUCHER spoke of the difficulty of satisfying all pilots, and suggested that when one of them said that such a machine had nice controls, this niceness was likely to be in each case merely a repetition of the control features of the machine with which the pilot concerned had had the greatest experience. MR. J. HARRISON complained incidentally of the fact that designers did not appear to take much notice of the varying size of human beings in the design of cockpits.

MR. H. B. IRVING thought that, in spite of their disadvantages, horn balances still provided the simplest solution to control problems, and said that they might come back for use, at least, on the elevator control surfaces. He suggested that balance should be obtained partly by the use of inset hinges and partly by horn extensions—the latter to take care of stick-free stability. He had heard that difficulties had been experienced with the controls of the D.C.4, and that the makers were going in for power assistance through the automatic pilot equipment.

MR. B. S. SHENSTONE gave an amusing instance of the fact that wind-tunnel tests on controls were not always right; in one case the controls should, according to tests, have been immovable, but at that very moment the machine concerned was flying quite satisfactorily. He did not see why motor assistance should be needed, and cited the case of the 50-ton Dornier Do.X, which had not needed such assistance. Power operation might, however, be used until such time as the designers had found means of obtaining satisfactory aerodynamic balance.

DR. G. V. LACHMANN stressed the point that it was impossible to describe "good" controls, and his idea was to reduce

Air Ministry Official Photograph, Crown Copyright.

The Irving aerodynamically balanced double flaps as experimentally fitted to a Miles Falcon. It will be seen that the balance would be neutral, with the airflow attempting to "raise" the lower half and "lower" the upper half

the unknown quantities as far as possible. It was comparatively easy to balance controls, but not always to satisfy the pilot—particularly in the matter of control co-ordination. He thought that elevator and aileron controls were the most important from this point of view, and demanded both accurate measurement of forces and of effort in relation to the resultant angular movement of the machine. Very large machines had their own special difficulties, and he believed that part-scale flying models would be essential in the future for the development of such types

MR. W. E. GRAY thought all that was necessary was that the pilot should be able to impose his will on the aeroplane. He did not believe that variable drag should be used to stretch a glide, but that rather the machine should be pointed at the aerodrome boundary and the air brake used to adjust the machine's speed. He asked what progress had been made in boundary layer experiments, and drew a diagram of the effect of his particular flap modification. He felt that designers and pilots should get together, and complained of the slow progress being made in the study of control problems.

SQN. LDR. H. P. FRASER agreed that machines should have much the same control characteristics now that pilots were being mass-produced, but suggested that it was right that machines for different purposes and of different sizes should have their own characteristics—in other words, that a fighter should be light and responsive, and a bomber heavy and not so responsive. The force required, in fact, ought to be relative to the response produced.

SQN. LDR. D. W. F. BONHAM-CARTER, in a particularly useful contribution from the pilot's point of view, said that, first of all, they required controls that worked; afterwards they could worry about lightness or heaviness. Not only must they work, but they must work at all speeds, and he remarked that in a number of modern high-speed machines the rudder control was rock-like at 200 m.p.h. The efficiency of controls seemed to him to be entirely wrapped up in the question of stability, which, he thought, might be adjustable. He cited the case of the dive-bomber which, to do its work satisfactorily, had to be somewhat unstable at other than dive-bombing speeds. He did not agree that a separate glide-control arrangement was a good thing, but would welcome it if this were interconnected with the throttle in such a way that further movement after closing the throttle would apply the air brakes. When plenty of drag was applied to a modern machine it was fairly easy to judge a forced-landing approach even with a high wing-loading; with the flaps down it was surprising how much height could be lost in quite a gentle turn. He did not agree that any standardisation of control weight and response was necessary.

Prof. Hill had only a matter of ten minutes in which to reply to all the questions, and he merely picked out the more important and interesting points. In the first place he did not himself believe in the idea of irreversible controls. In theory the twisting of a whole wing to make a turn was good, but all control difficulties were increasing with the size of machines. He agreed that a pilot's opinions of "good" controls depended very much on what he was used to. Following Mr. Irving's remarks about power control for the D.C.4, he suggested that if this were true it must be a poor aeroplane. He had flown a Short Sunderland, and in this the controls were light and pleasant. He was entirely in favour of the flying scale model for initial experimental work in the development of large machines, and explained that when he used the word control "feel" he automatically included the machine's response to the pilot's efforts in each combination of control movement.

THE MINISTRY MOVES IN

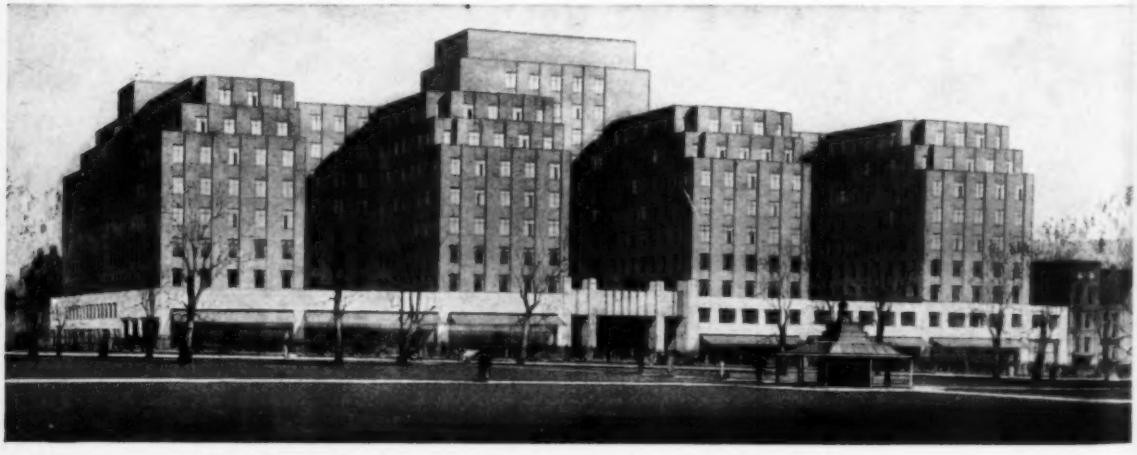
NOBODY could say that the outside view of Berkeley Square House really adds to the architectural beauties of the greatest capital in the world, or preserves the peculiar atmosphere which one has associated with the square where "Tomlinson gave up the ghost." It is modern; still more, it is modernistic; but it is eminently convenient inside. It towers into the air to a height of 180 feet, it provides 330,000 square feet of space for the Air Member for Development and Production and all the Directorates of the Air Ministry which deal with production of aircraft, engines, etc.—an area divided into rooms and corridors by seven miles of partitioning; and to walk all over the Air Ministry part of the building would mean a tramp of thirty miles.

This utilitarian monster is not, as some suppose, to be the headquarters of the Air Ministry. Adastral House retains that dignity until such time as the projected new building in Whitehall becomes an accomplished fact. Berkeley Square House is to relieve the pressure on Adastral House and other Air Ministry quarters and to house in one building a great and growing staff which had previously been spread over twelve.

The official opening by Sir Kingsley Wood took place on Tuesday of last week. The ceremony was held in the entrance hall on the ground floor, a huge garage-like space flanked with what are to be shops and illuminated by cunning lights in the roof of pink and other colours, suggesting the modern architect's idea of the entrance to the magician's cave. Sir Philip Sassoon, now First Commissioner of Works, compared the effect with "the rosy-fingered dawn." The dawn, we all hope, will be one of new methods of aeronautical production, and the magicians above will, we also hope, do wonders in the way of extracting Spitfires and Tauri (or Tauruses) from their sleeves and their top hats.

In his speech the Air Minister explained that expansion of the R.A.F. had involved an increase in the Air Ministry staff from some 1,800 persons to 5,500, and the indications were that further increases would be necessary. He paid a tribute to the close co-operation between the builders, Sir Robert McAlpine and Sons; the agents, Knight, Frank and Rutley, and the Office of Works. He said that the cost of the building was no greater than that of the older and less suitable buildings in Kingsway. Sir Philip Sassoon spoke for the Office of Works, and Mr. W. Gibson, of Knight, Frank and Rutley, made a very neat little speech on behalf of the other parties.

The Air Minister then went up to the roof in one of the very super-excellent and ornamental lifts and hoisted the R.A.F. Ensign on the mast at the top.



Berkeley Square House, the vast new West End home of the Air Ministry

CONSTRUCTION and AERODYNAMICS

Basic Considerations that the Aircraft Builder must Keep in Mind: How Design has Progressed: The Future Outlook

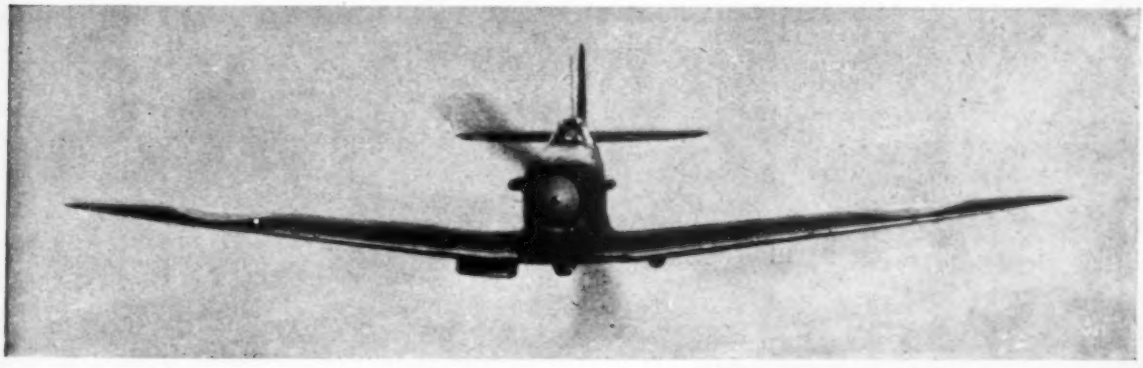
By THE EDITOR

(Illustrated mainly with "Flight" photographs)

AIRCRAFT performance has, from the early days of flying, progressed in a series of bounds, beginning with those made by the first fliers, whose initial efforts were short hops of a few yards, if indeed the machines succeeded in getting off at all. More often than not, the power was inadequate and there was more taxying than flying. The Wright Brothers overcame the difficulty by using a dropping weight and a starting rail, thus being not only the first men to fly under proper control, but also the first to use "assisted take-off," an auxiliary which has been revived in modern times, although for a different reason.

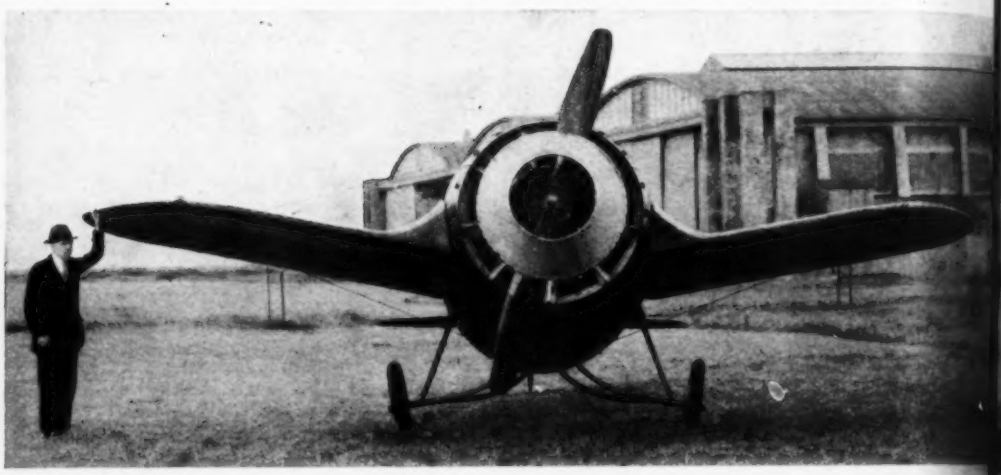
For some years after the Wrights had conclusively demonstrated that flying was possible there was little improvement in performance, the main reason being that the engines available were of very low power (40-50 b.h.p.).

The D.H. Albatross (in the heading) probably represents the maximum aerodynamic efficiency attainable with a wing-fuselage combination. Further progress must be towards attaining the "all-wing" ideal.



The little Sopwith biplane of 1913-14 set a standard, for the time, of aerodynamic efficiency. Above and right: The modern formula—the clean lines of entry of the present-day fighter, as exemplified in the Supermarine Spitfire and the Hawker Hurricane with their Rolls-Royce Merlin engines.

(Above) A famous "private venture": The Fairey Fox set a new fashion in aerodynamic cleanness for biplanes.



(Right) The first British retracting undercarriage was fitted on a Bristol racing monoplane in 1922. Note the cycle spoke-braced spinner

but due also to the almost complete lack of knowledge of the importance of reducing drag by suppressing all avoidable excrescences and of what we now term "streamlining."

Then came the introduction of light power plants, such as the rotary Gnome engine, and the result was that instead of staggering through the air with just enough power to keep from sinking, aeroplanes began to have a little power reserve, or, in other words, the speed range began to widen out and speeds improved. Previously the aeroplanes had been almost "tangent," an expression which arose from the fact that the "horse-power-available" curve was almost a tangent to the "horse-power-required" curve.

By the time the war 1914-18 started, engines had become available which developed about 100 b.h.p., and not only had two-seaters been built which flew quite strongly, but larger aeroplanes which, by being very lightly built and loaded to no more than 3-4 pounds per square foot of wing area, were able to carry quite considerable loads, although at very low speeds.

The stimulus of the war produced engines of much greater power than those which had been available, and the extra power was immediately reflected in a marked improvement in performance. This, however, was obtained by brute force and ignorance rather than by scientific aerodynamic design. Results had to be obtained quickly during the war, and there was little time for experimentation. But one of the bounds in performance did coincide with the war period. Many regarded this as a sign that the war had helped to develop flying. To the extent that it produced better engines, that was so, but if aircraft designers had not had the more powerful engines, and had time been available for serious study, they would have achieved at least part of the improvement in performance by better aircraft design and not merely by putting in more powerful engines.

The early post-war period saw the performance curve flatten out, and there were many who believed that very much greater speeds than those attained by the fastest war-time machines were not to be expected. In the meantime, research got a chance to get to work, and the fundamental principles of airflow began to be better understood. The urgency of production had disappeared, and it became possible to think in terms of efficiency. The tractor biplane had become established during the war, and it was natural that this type should form the basis of further development.

As the biplane type was gradually "cleaned up" by using better fuselage shapes, reducing the number of struts and wires in the undercarriage and wing bracing, and as more powerful engines were developed, the speed curve began to rise once more and then tended to flatten out. Air races did much to produce "high spots" in the matter of maximum speeds, and particularly the series of contests for the Schneider seaplane trophy. These taught designers the world over the importance of streamlining and of avoiding all projections which were not absolutely essential.

For a number of years the lessons learned were not applied to Service aircraft, mainly because it was considered impossible to get the necessary military equipment into the very small compass of the racing monoplanes which had from year to year won the Schneider contests. Another factor which delayed the general adoption of the monoplane type was the fact that the biplane, with its shorter wing span and lower moments of inertia, was held to be fundamentally better capable of rapid manœuvres than the monoplane. This view had persisted from the war days, when in "dog-fights" manœuvrability was often of greater advantage than mere speed.

It was natural that the adherence to the biplane arrangement should keep the speed curve from rising very rapidly, and once more the pessimists trotted out their view that we had approached something like finality in aircraft speed unless the speed were to be paid for very dearly in increased power expenditure. And truly there was some excuse for being pessimistic. At the speeds which were being attained by biplanes, thanks to more powerful engines, the drag of the undercarriage formed a very large percentage of the total drag, and although retractable undercarriages had been used on biplanes, they did not find favour with British designers, mainly because they took up too much valuable space inside the fuselage, space which was needed for military loads and equipment.

During the last seven or eight years there has been another bound in performance, at any rate as regards military and commercial aircraft as distinct from pure racing machines. In fact, this bound is the greatest in the history of flying if one remembers that it is not confined to one

type or even to a few types, but is almost universal. And, as was to be expected, the pessimists are again saying that we have almost reached the limit. Past history has always shown the pessimists wrong, and future history will probably refute them again, although it does seem that just now we are approaching another flat spot on the performance curve.

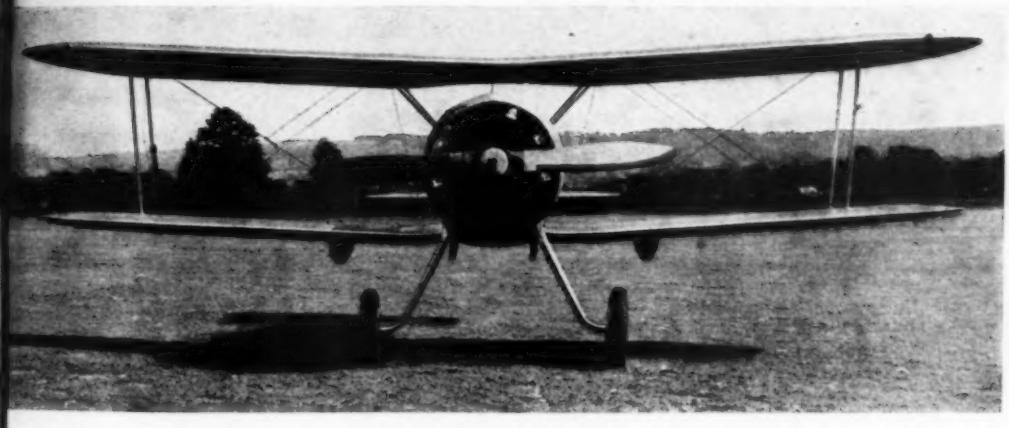
To appreciate the steps which have led to the present high performances of aircraft it is necessary to review a very wide field, but very briefly it can be said that, apart from the obvious influence on performance of the wonderful modern power plants with which our engine firms have supplied us, the spectacular speeds now being attained by Service and commercial aircraft alike can be ascribed to the use of such devices as retractable undercarriages, variable-pitch airscrews and, indirectly, to trailing-edge flaps. Under the heading of engines should, of course, be included the much lower cooling drag which modern engine cowlings have made possible.

The first step towards real improvement in aerodynamic efficiency was the change-over from the braced biplane to the cantilever monoplane. That in itself would not have achieved any very marked gain in speed for a given power, because the profile drag of the thick wing, demanded by structural considerations, would have been nearly as great as the lower drag of the thin biplane wings plus the drag of their external bracing. But the thick monoplane wing did make possible the retraction of the undercarriage into the wing in such a way that most of the undercarriage was buried inside the wing. That put the speed up a great deal, and it was natural that the low-wing position should has now become almost stereotyped in its universality.

In the single-engined monoplane it is essential, if the undercarriage is to disappear completely, that the wheels should be retracted by being swung sideways so that the wheel lies horizontally. The movement can, of course, be inward or outward, and the choice is mostly determined by the nature and placing of the equipment carried inside the wing. The inwardly swinging undercarriage leg gives a wider wheel track and thus greater stability on the ground, but the space occupied by the wheels, inside the wing roots adjacent to the fuselage, is sometimes needed for tanks, guns or bombs.

With twin-engined or four-engined monoplanes there is a wider choice because usually the engine nacelles afford good stowage space for the wheels in the retracted position. Retraction can, therefore, be in a forward or rearward direction, which is simpler mechanically than sideways retraction. The manner in which different designers have attacked the problem is dealt with in a separate article elsewhere in this issue.

In the meantime, the placing of the wing near the bottom of the fuselage had been found by research in wind tunnels to be the very worst possible. "Worst" from the point of view of interference, that is. In the earlier days of flying it was customary to measure in the wind tunnel the lift and drag of wings of a certain section and a certain aspect ratio (usually six), and the drag of the fuselage which it was intended should go with the wings. The total drag of the complete aeroplane was then assumed to be the sum of the wing drag and fuselage-cum-tail-cum-undercarriage drag. Tests showed that this was rarely the case,

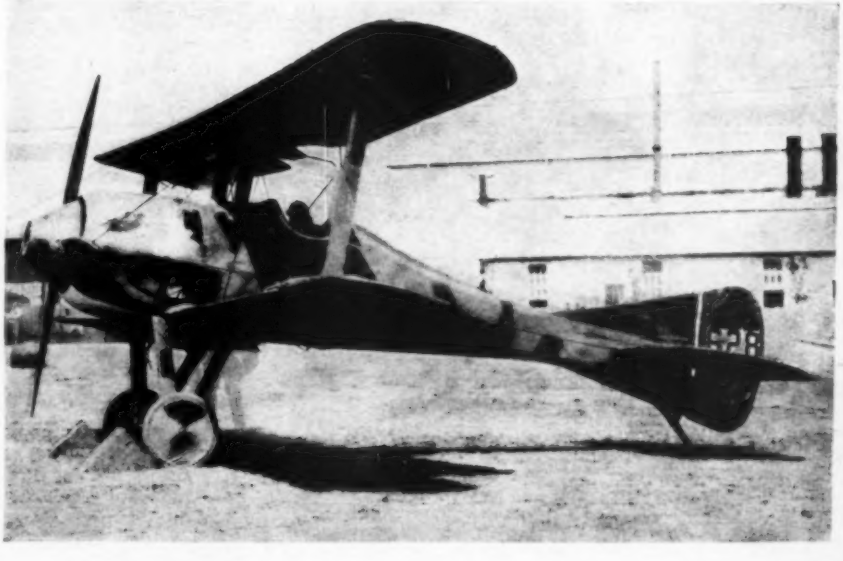


(Left) Dowty internally sprung wheels simplify the biplane's undercarriage problem in the case of the Gloster Gladiator.

(Below) Ahead of its time: The S.E.4, designed and built at the Royal Aircraft Factory (now Establishment) in 1914, had long-chord engine cowl, streamline fuselage, faired strut joints, spinner over the airscrew, and trailing-edge lift flaps.

be selected because it meant that the struts of the undercarriage could be kept quite short, and retraction became simpler.

At first the retractable undercarriage was applied to single-engined aeroplanes. In this country, and it deserves to be placed on record, the first designer to use a retractable undercarriage (apart from an experimental racing monoplane built by the Bristol company many years previously) was Mr. Tiltman of Airspeeds, whose little Courier monoplane was extremely efficient and had a good performance with very modest power. It was not long, however, before the principle was applied to twin-engined machines, and thus began the evolution of the general type of layout which



(Top) Ultimate winner of the Schneider Trophy and for a time holder of the world's seaplane speed record: The Supermarine S.6 B with Rolls-Royce "R" engine of 2,300 b.h.p.

(Below) The Gloster IV Schneider seaplane was probably the most efficient biplane which could possibly be designed.

and that the total drag was always greater, and sometimes a good deal greater, than the sum of the item drags.

This extra drag became known as "interference drag" because it was thought to be due to the mutual effect of one part of the aeroplane on another part. A fruitful source of interference drag was the junction of wing and fuselage. On a flat-sided fuselage, with the wing set half-way up the sides, the interference was found not to be very great. If, however, the fuselage was of circular or elliptical cross-section, and the wing was set low on it, the interference became pronounced, and the combination drag far exceeded the sum of the individual drags. Unscientifically this was thought to be quite natural, as the air would be "jammed" in the narrow angle between the curved sides of the fuselage and the top of the wing root.

Diverging Air Flow

Examined in a slightly more critical spirit, the interference between fuselage and wing root was found to be due to the rapidly divergent flow of the air in the neighbourhood. After being pushed out of the way by the nose of the fuselage and the leading edge of the wings, the air had to be "spread out" fairly suddenly because the inward curve of the lower portion of the fuselage and the downward curve of the top of the wing root left a larger volume to be filled by the air. This diverging flow could not be accelerated in time, and the result was that instead of following the wing and fuselage surfaces, the air became turbulent and "broke away," causing disturbed eddies which not only increased the drag but which might, and often did, cause tail flutter.

To allow the airstreams to meet again without too-sudden expansion after passing over the maximum cross-section of the fuselage and the highest point on the upper wing surface, the angle was filled in by a fairing, of short radius at the topmost point of the wing and of increasing radius towards the trailing edge. This type of fairing has become known as a wing fillet, and is found on most low-wing monoplanes.

Having "cleaned-up" his aeroplane to the best of his ability, and having succeeded in lowering the drag very considerably, with consequent gain of speed, the designer was faced with another problem. In the old biplane days the maximum speeds attained were not very great, which is merely another way of saying that the speed range was not very wide. Consequently the airscrew pitch was not anything like as great as it is in modern high-speed aeroplanes. That meant that during the early stages of the take-off the airscrew blades were not seriously stalled, and the thrust obtained, even at fairly low forward speeds, was reasonably good. But when he had improved his performance by suppressing all excrescences the designer discovered that the coarse pitch needed for high maximum or cruising speeds caused the airscrew blades to stall during take-off. The result was that the new efficient machines had a very poor take-off. For single-seater fighters this was not so pronounced, because that type of aeroplane had in any case such an enormous reserve of power that even with the airscrew stalled during the early stages of the take-off the run was not excessive. But for heavily loaded bombers, and for commercial aeroplanes, it was another matter. In extreme cases it might mean that the payload was limited not by what the machine would carry, but by the distance it took to clear the obstacle stipulated in the regulations governing the issue of Certificates of Airworthiness.

As soon as this very fundamental fact was realised (and it took quite a long time, particularly in this country) the variable-pitch airscrew came into its own. Up till then Dr Hele-Shaw and a few others had been voices crying in the wilderness. Farnborough was not interested, and designers believed in giving the Air Ministry what it wanted, or what it thought it wanted. And so the variable-pitch airscrew was left alone so far as official encouragement was concerned. One company, the Gloster, did see that the variable-pitch airscrew was bound to be needed sooner or later, and carried out a great deal of development work. With the assistance of firms like Bristol and Rolls-Royce, and a somewhat belated support from the Air Ministry, the good work was continued, and the Hele-Shaw is now become the Rotol. In the meantime the American Hamilton Standard v.p. airscrew had been Anglicised *via* the De Havilland firm, and is now found on very large numbers of aircraft.

An Aerodynamic Gear Box

The fundamental principle of the v.p. airscrew is, of course, simple enough: Fine pitch, which allows the engine to attain its maximum permissible take-off revolutions, is used for the take-off. For cruising or for full speed the airscrew is put into coarse pitch. In other words, the v.p. airscrew is a "gear box." The intricacies of the mechanical solutions of different designers are dealt with elsewhere.

It must not be thought that the aircraft designer was satisfied when he found that he had obtained a very great increase in speed by keeping his aeroplane "clean" and that he could get it into the air by using v.p. airscrews. He at once looked about him for other means of increasing performance. The v.p. airscrew had helped him to get the machine off the ground very quickly. It was therefore obvious that he could afford to increase his wing loading and still retain a fairly good take-off. But then came the vexed question of landing speeds. Pilots, being conservative folk, will grumble like fun about any great change from that to which they are accustomed. But in the end they give in, and before long they take the new

The Airspeed Courier was the first British utility aeroplane to use a retractable undercarriage.

circumstances as a matter of course. So also with landing speeds. If broken-in gradually and gently, the wily designer thought, the pilots would put up with considerably higher landing speeds. And then landing speeds began to creep up. From 45-50 m.p.h. they went to 55-60 and from there to 65-70 m.p.h. Pilots became accustomed to these speeds, especially as lateral control at low speed had been considerably improved, even if a long way from perfect.

When a large aerodrome was available, the higher landing speed did not matter, but the increased landing speeds, coupled with the greater aerodynamic cleanness of the aeroplane, brought with them another difficulty: after making his approach at a safe speed the pilot found that the aeroplane covered a great distance before losing speed. It could not be landed just inside the boundary because as soon as the nose was put down it gathered speed, and if the tail was dropped the machine climbed again. Obviously what was wanted was some form of air brake, or better still from the designer's point of view, a device which would increase lift as well as drag, the latter more than the former. If such a device were available, not only would the gliding path of the aeroplane become steeper but the actual landing speed would be lower. Or, if the same landing speed could be tolerated, the wing loading could be even further increased.

The trailing-edge flap was the answer to the designer's prayer. It now exists in many different forms. In some it acts mainly as an air brake. In others it gives increase in lift as well, partly because of its angle, and partly, in some cases, because it actually increases the wing area by being pushed backwards as well as downwards. The idiosyncrasies of flaps are dealt with in another article.

Time to Call a Halt

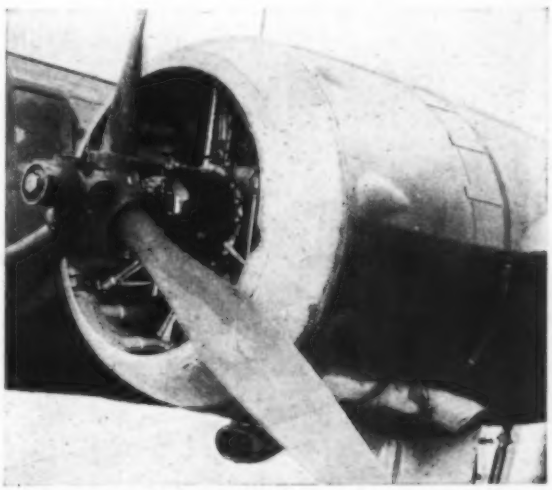
And so we have come to the modern aeroplane. The evolution sketched in above notes is not strictly correct, chronologically speaking, but the thought processes of the designer were very much as outlined. The present high wing loadings have come to stay, and in military aircraft they may even be increased. It is to be hoped that in commercial aeroplanes a halt will be called. In spite of the amazing reliability of modern aero engines, which has rid us of that bugbear of the early days of commercial aviation—the hurried forced landing, accidents continue to occur with distressing frequency.

For very long flights a further increase in wing loading may be justified. It has been demonstrated recently that a flying boat can be taken off under its own power with a wing loading of more than 30 lb./sq. ft. If loadings of the order of 40 lb./sq. ft. are adopted some form of assisted take-off will probably be needed. This may take the form of refuelling in the air, composite aircraft, or some form of catapult or accelerator. The gain to be expected above wing loadings of about 40 lb./sq. ft. is not great, and the advantages of high-wing loadings are soon lost if another aid to increased speed is adopted, *i.e.*, flying high.

The lines along which development is likely to move in the near future in order to obtain still greater speed, particularly for long-range work, are increased wing loadings for flight at medium altitudes, and so-called sub-stratosphere flying (at 25,000 to 30,000ft.) in order to take advantage of the fact that at those heights the density of the air is considerably less than one-half of the density at sea level. This means that the resistance to forward motion is correspondingly smaller, and a material increase in speed may be expected.

All the worth-while things in this world have to be fought for, and so also with the speed which height confers. The power of the engine depends upon the weight of the charge drawn into the cylinders on each induction stroke, and as this charge decreases with height, being approximately one-half at 20,000ft., the engine power also falls off with height. The supercharger is designed to maintain sea-level pressure up to a certain height, called the rated height of the engine. With two-speed superchargers there is no difficulty nowadays in maintaining the power at the heights at which it is contemplated that "sub-stratosphere flying" should take place. The trouble comes from the human freight on board. Test pilots frequently have to fly at 20,000ft. or more. They are equipped with oxygen bottles in order to remedy the deficiency in oxygen at those heights, but obviously one could not expect fare-paying passengers to put up with having to wear such equipment. The alternative is an airtight cabin in which the air is maintained at a constant pressure, irrespective of the pressure which exists outside.

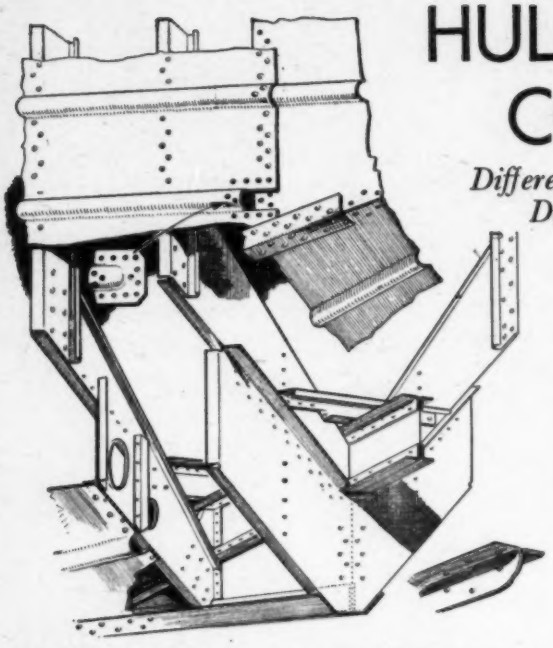
There are very considerable mechanical difficulties in keeping a cabin airtight, particularly when controls have to be taken through it, but there is no doubt that pressure cabins, as they are sometimes called, will be a feature of the commercial aeroplanes of the immediate future. Already machines are being built which incorporate such cabins. A certain amount of extra weight is entailed, partly in making the actual structure airtight and partly the weight of extra equipment, blowers, generators and suchlike. That is part of the price which has to be paid for the extra speed expected.



The aerodynamic aspect of radial-engine installation: Bristol Mercury VIII in long-chord cowling, seen with cooling gills closed.

HULL and FUSELAGE CONSTRUCTION

Different Methods Compared : Installation Difficulties with Small Monocoques



In the Saro London flying boats a somewhat unusual type of planking is used. Instead of riveted-on stringers, the planking itself has widely-spaced corrugations. This construction makes for simplicity.

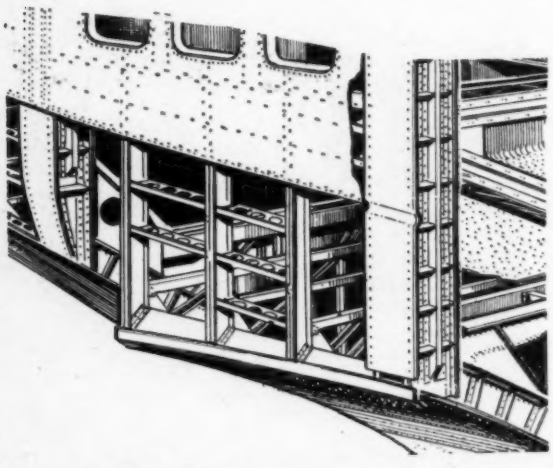
WITH the demand for high performance during the last few years has come the necessity for using perfect streamline forms and smooth finishes. Skin friction plays an important part at high speeds, and any roughness of surface or departure from smooth lines has a considerable effect on drag. Hence the introduction of the metal monocoque or semi-monocoque construction. Flying-boat designers had to face the problem much sooner than landplane designers, although for a different reason. In the landplane sheer performance has forced the metal covering on the designer. In the flying-boat the need arose largely because of the liability to water soakage of wooden hulls. In a boat of average size this might amount to several hundred pounds. Consequently metal-covered hulls came into use several years before metal-covered fuselages.

Fundamentally the principles involved in the construction of a hull and a fuselage are similar. But the hull designer is faced with certain problems which do not arise in the design of a fuselage. These are chiefly due to the fact that the hull has to have a planing bottom the plating of which is capable of standing up to the impact of the water. Moreover, it becomes necessary to introduce steps, which cause a break in the main structure and thus add considerable complication. In other respects the two types of construction are very similar.

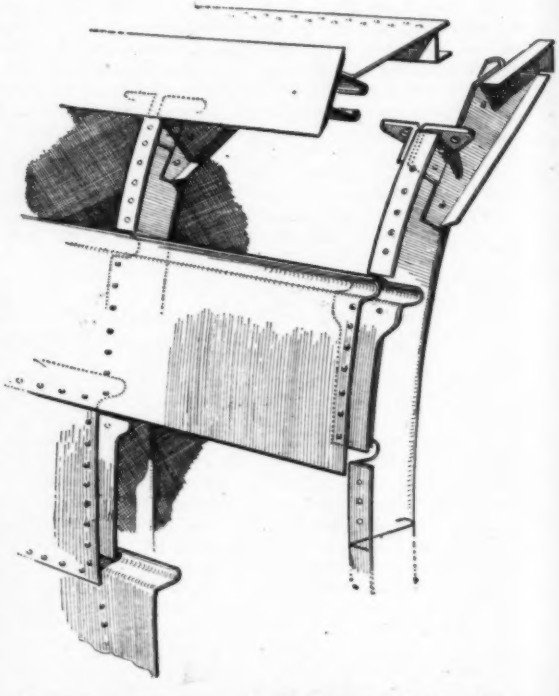
The hull of a flying boat and the fuselage of a landplane may be regarded as a hollow beam which has to carry bending loads caused by air loads on the tail at one end and certain other concentrated loads along its length and possibly in the nose (the engine in the case of a single-engined landplane fuselage). In addition, the beam has to be capable of resisting torsion.

If the fuselage were a plain cigar-shaped body it would be possible to make a very light structure. Unfortunately it has to have various openings in it, and as soon as a hole has to be cut in the covering it becomes necessary to provide paths for the stresses around the opening. This fact introduces complications and adds considerably to the weight.

In the basic design of a monocoque fuselage or flying-boat hull the general scheme is to have a series of hoops or rings which provide the cross-section at any given point, and to rivet to these rings or frames the outside sheet covering. If the material used for the covering were light enough, so that it could be used without reinforcement, a true monocoque (shell) could be made. With materials available at present this is not possible, and the duralumin



The longitudinal stringers in the Short Empire boats are interrupted at the frames, which are uncut.



By curling over one edge of each fuselage "plank," stringers are avoided in the Fairey Battle, and one row of rivets is saved.

or Alclad sheet used for covering has to be so thin that it would have but little strength under compressive loads. To enable it to withstand these the covering is reinforced by stringers running fore and aft.

The rings in a fuselage or the frames in a flying-boat hull are usually either of plain channel section or of Z-section. The stringers are generally Z-section, U-section or V-section. The choice depends upon the method used at intersection of stringers and frames, and on whether the outer covering is attached to stringers only or to frames as well as stringers. An advantage of the Z-stringer is that it is usually more accessible for riveting.

In some constructions the skin is attached to the stringers only. The advantage of this form of construction is that as the skin is spaced away from the frames no transverse ridges can be formed in the covering, and as these have a greater effect on drag than have longitudinal ridges, a slightly more efficient form may result.

Ways and Means

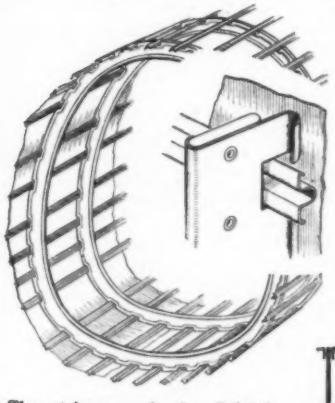
Where stringers and frames intersect, it becomes necessary to cut one or the other. Designers are by no means unanimous in their choice, some using one method and others the other. In the Short boats, for example, the frames are continuous, and the stringers are interrupted at the intersection. In one class of Supermarine flying boat the frames are cut, and in another the stringers. Whichever is chosen it becomes necessary to tie frames and stringers together, and this is usually effected by small gussets.

Instead of using separate stringers riveted to the skin the latter may be made up of long, narrow planks put on longitudinally, and it then becomes possible to curl over one edge of each plank, the curled edge providing the stiffening. One row of rivets along the edge of the plank may then be made to suffice. This principle of the curled edge is used in the fuselage of the Fairey Battle, for instance.

That the metal-clad fuselage has certain aerodynamic advantages due to the perfection of its form and the smoothness of its surface will not be denied. Another point in its favour is that it gives more room inside for a given cross-section than a girder type of fuselage, in which the inscribed rectangle formed by the girder structure inside the oval of the outer cross-section wastes a certain amount of space that could otherwise be utilised.

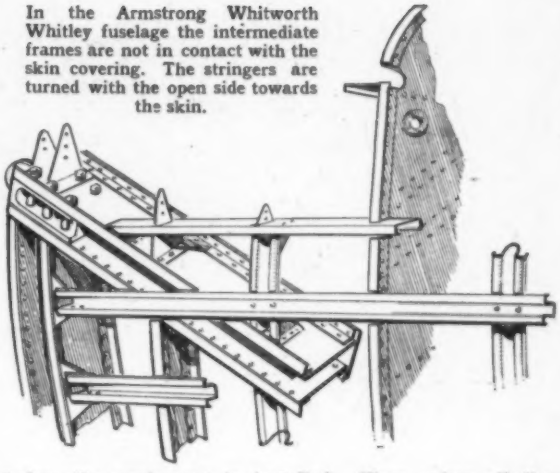
There is, however, something to be said for the girder type of fuselage, especially in the smaller sizes. Inside a small monocoque fuselage there is very little room for men to work when installing equipment. With the open girder fuselage men can stand outside and reach in between the girder members.

It may be possible to reduce this drawback by so designing the monocoque structure that only the lower part is planked



The stringers of the Bristol Blenheim are notched into the frames, and have their backs turned towards the skin, thus making one row of rivets suffice.

In the Armstrong Whitworth Whitley fuselage the intermediate frames are not in contact with the skin covering. The stringers are turned with the open side towards the skin.



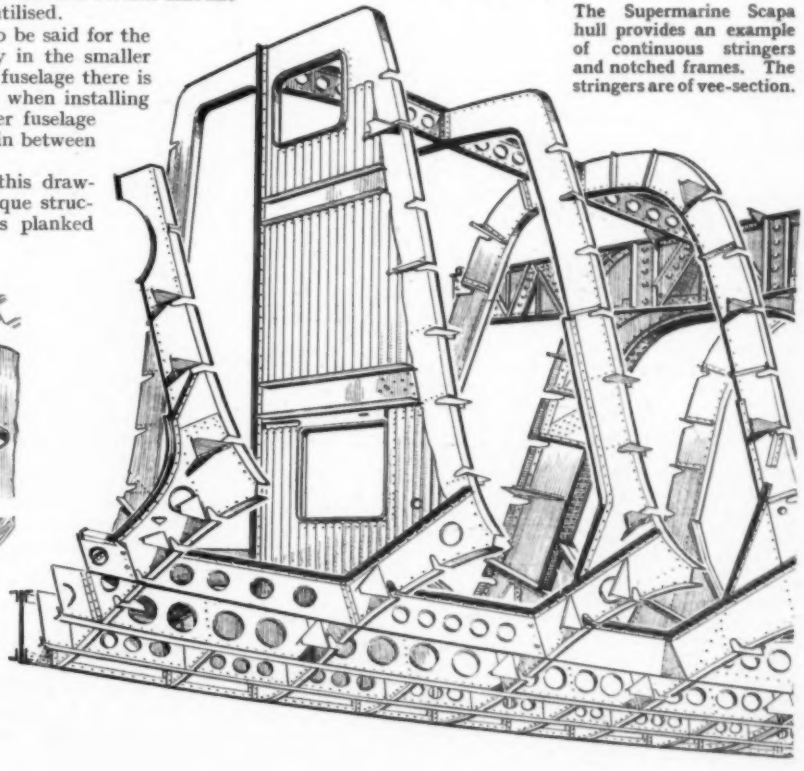
before the equipment is installed. Then, when all the equipment is in place, the "lid" can be put on and riveted or bolted into place to complete the fuselage structure. Examples in which this principle has been adopted are already in existence, and it seems likely that the custom will spread.

Geodetic Construction

A type of construction which may be said to lie between the monocoque and the girder is the geodetic. In this the structural members are of girder type, arranged in the form of a number of spirals running around the fuselage in opposite directions. But the monocoque principle is involved in that the stresses are made to travel over the surface, or nearly so, and not along straight members, as in the normal girder. By crossing the geodesics of opposite spirals and fastening them together at the nodal points, the tension members are made to relieve the loads in the compression members, and vice versa. Metal covering *could* be used in conjunction with geodetic construction, but hitherto this has not been done.

(*Wing construction is dealt with on pages* 544-549.)

The Supermarine Scapa hull provides an example of continuous stringers and notched frames. The stringers are of vee-section.



The vast area of the Fowler type of flap is admirably shown in this photograph of a Lockheed 14 coming in to land.

VARIABLE LIFT and DRAG

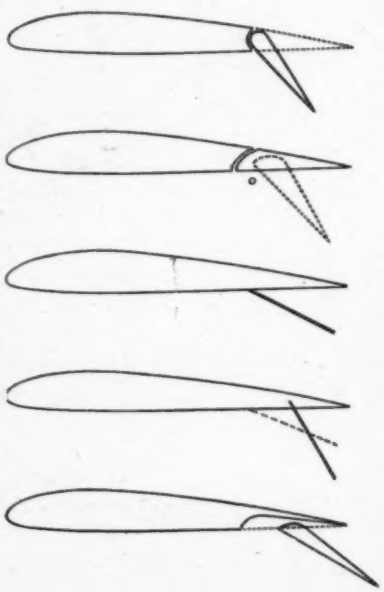
Changing Ideas on Slots and Flaps : Making the Best of Both Worlds : "Composite" Wings

By H. A. TAYLOR

FROM the very earliest days of flying increase in performance has only been obtained through an increase in wing loading. It is only during the past five years or so, however, that this loading has increased to such an extent that means have had to be found to vary the characteristics of a wing to suit the particular circumstances of the take-off and landing.

Theoretically, the best way of dealing with this problem would be to arrange a variable wing area and/or a variable wing section. For the present, at least, this is a mechanical and structural impossibility, and it has so far been necessary to devise other means by which the lift of a wing can be increased when necessary to provide something resembling a Jekyll and Hyde machine which is capable of very high speeds and yet at the same time can be modified to fly with real safety.

There is nothing new about the basic idea behind the two aids which are at present used to obtain these results—slots and flaps—but the tremendous increase in performance during recent years has necessitated their rapid development both separately and together. Probably it was the commercial introduction of the controllable-pitch airscrew, as an aid to take off, which first gave us, for better or worse, wing loadings of the scale utilised to-day even on civil transport types. Flaps were then redeveloped in the first place with the idea of increasing lift, and were then treated for a year or two very largely as "form destroyers" — in other words as a means by which an otherwise flat approach could be steepened in order to simplify entry at a safely high speed into normal-sized aerodromes.



Five examples of flap design. From the top diagram downwards they are respectively: plain camber - changing, H.P. slotted, split, Zap, and Fowler. The split type is most commonly used nowadays, but there is a demand for more lift without extra drag at small flap angles—hence the increased use of the slotted type.

Now, with the demand for still higher wing loadings there is a tendency to return to the original idea of increasing lift, with drag increase as a secondary consideration. In nearly all classes of machine landing speeds appear to have reached the reasonable maximum, and any further increase in loading is only possible if high-lift devices are, at the same time, introduced in commercial form.

The wings of a modern machine can no longer be considered as a single structure, but rather as a composite. In addition to the main wing there are supplementary airofoil surfaces which come into action when necessary, but which in normal flight are part and parcel of the main lifting surface, so that they do not reduce the machine's cleanliness in the ordinary way.

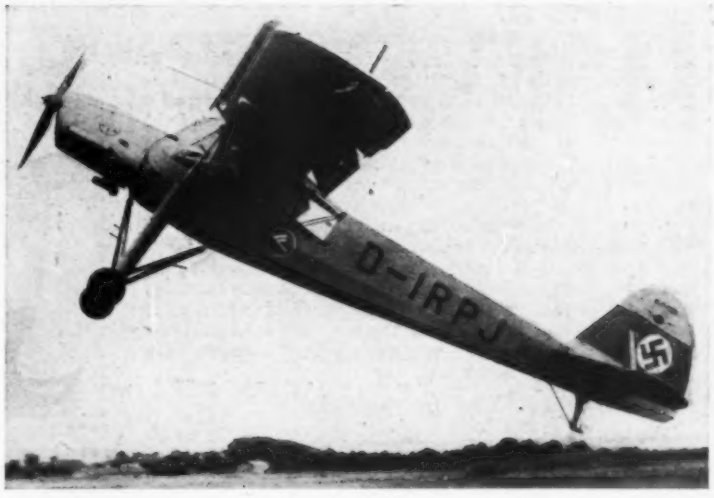
At the present time a number of possible combinations and variations of high lift items are being considered, but it will perhaps be simpler if some flap types are first described.

Present Flap Design

First, there is the camber-changing type, in which part of the trailing edge of the wing is hinged and its position controllable. Secondly, there is the split flap, at present the most widely used type, which may be described as one in which the flap surface makes up a part of the lower side of the trailing edge; when it is lowered the upper surface of the wing remains intact. This type of flap was originally known as the Schrenk, after its inventor's name. Then there is a variation of the split flap, the Zap (after its inventor, Zaparka), in which the leading edge of the movable surface slides back as the flap is lowered in such a way that the trailing edge remains below that of the wing.

Fourthly, there are the Handley Page slotted and Junkers flaps in which the rear portion of the wing is hinged in such a way as to leave an aerodynamically designed slot between the main wing and the leading edge of the flap when this is moved into the "down" position. Finally, there is the Fowler type of flap, which may be described as a combination of the slotted and Zap types. In this the movable surface, as it is lowered, slides rearwards on guides, with the result that a considerable increase in wing area is provided, while the shape of its leading edge, in relation to the recess into which it normally fits when retracted, is such that the airflow is properly controlled. The Gouge flap, used on the Short boats, is somewhat similar, though differing in detail.

The plain split flap, which was first used on the Northrop Sky Chief in 1932 (when experiments were conducted with full-span flaps and "park bench" ailerons) has served its purpose of reducing, when necessary, the cleanliness of modern machines, but it appears to have had



Making the most of slots and flaps—the Fieseler *Storch*, which has been designed for Army co-operation and communication work. It is seen here in a typical demonstration take-off attitude.

its day. The type certainly provides plenty of drag when in the fully down position, but even at comparatively small angles it offers rather too much of such drag for real take-off assistance; although at small angles it increases the lift and so shortens the take-off run, this lift increase is accompanied by an increase in drag, and the advantages of a more rapid take-off are outbalanced by an initially poor rate of climb.

At the present time—and disregarding, for the moment, the use of leading edge slots—the slotted flap possibly offers the best all-round answer to the demand for a device which increases lift to a useful degree, and, when necessary, increases drag. At an angle of 60 deg., for approach and landing purposes, the drag is considerable enough, yet, at a take-off setting of approximately 30 deg. the increase of lift is useful and the amount of drag is very small. Furthermore, this type of flap, because of its necessary hinge moment, is more or less aerodynamically balanced, and the necessary control mechanism can, therefore, be comparatively light and simple.

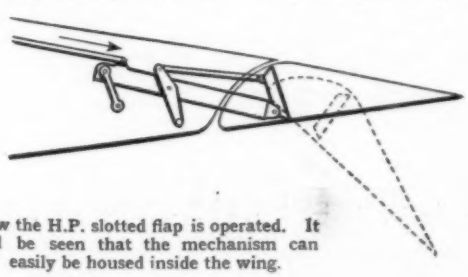
So far, the Fowler flap, which is very good in theory, has not shown all its good points in practice. Its disadvantages include mechanical complication, and the necessity for the addition of fairly large supporting brackets and guides. These difficulties are increased by the fact that a comparatively large proportion of the total lift of the wing is taken by the flap. So far, too, it has not been found possible, in practice, to use the Fowler satisfactorily for take-off purposes. The reason for this seems partly to be that the drag is greater than it should be, and partly that ground deflection of the downwash may sometimes make it impossible to use the angle required for maximum lift. This last difficulty should be nullified if the flaps are used in conjunction with a "level landing" or tricycle undercarriage.

Lateral Control Difficulties

Except in the case of purely experimental work, full-span flaps have not been used for the reason that it is necessary, with them, to provide some new type of lateral control. In earlier experiments the "park bench" type of aileron—which is, in effect, a control surface mounted above the wing—was used, but these were not very successful, and research work is still going on, not too hopefully, in the development of spoilers.

In theory, it should be possible to continue the use of normal ailerons even with full-span flaps, since only the upward movement of these control surfaces is of real value. Some years ago a Fieseler type was designed with ailerons having only an upward movement, but the necessary restriction arrangements made them very heavy in operation. More recently, P.Z.L. have been making use of this system, and an example of a machine with full-span flaps was shown at the Paris Salon.

It is doubtful, however, whether there is any real value in attempting to provide these full-span flaps as they tend to make a machine unstable at low speeds. Drooping ailerons, used in conjunction with part-span flaps, have also been tried and have proved quite successful, though the amount of droop must necessarily be very much less than that normally demanded in a flap. Where wing-tip slots are fitted with part-span flaps, these slots have something of the effect of full-span flaps, but do not introduce the necessity for designing a new type of lateral control.



How the H.P. slotted flap is operated. It will be seen that the mechanism can easily be housed inside the wing.

Leading edge slots were first introduced as a means by which the stall could be more generally distributed over the whole wing. Usually, particularly with the tapered wings, the stall starts at the outer portion, causing the wing to drop at a speed at which aileron control is usually non-existent, or even reversed. Several very interesting machines were produced—notably the Handley Page *Gugnunc*—in which the slot principle was carried almost to its logical conclusion. More recently, the use of flaps has meant that some means had to be found to match up the characteristics of the flapped and unflapped sections of the wing. In this case, as previously remarked, the wing tip slot may be considered as a practical extension of the flap principle over the whole span.

Very briefly the slot, when open, delays the stall of a wing by acting on the boundary layer in such a way as to prevent the airflow from breaking away. Other means have been devised of obtaining the same results—notably the Mattioli Diruptor, which consists of a thin rod supported near the leading edge of the wing—but the slot is undoubtedly the best known, and has the particular advantage that, when not in use, it is buried in the leading edge and causes no additional drag. In special cases fixed or permanently open slots have been fitted, but where high efficiency machines are being considered these can be ignored.

Air Brakes

For such machines the design of flaps is likely to alter progressively, though for smaller types, in which performance is not the final criterion, flaps may continue to be used almost entirely as a means of air-braking. In this case it seems almost unnecessary to go to the trouble of providing flaps as such, when any form of braking area could be applied. The latter, too, would rid the pilot of that slight worry caused by the fact that additional lift is provided through a certain initial angle of the flap. Beyond an angle of, say, thirty degrees to the horizontal, flaps do not provide any additional lift, and the whole of this movement can be used purely and simply as an air-brake.

There are differences of opinion as to whether flap control should be quick in action, but it is generally agreed that it should be so, provided, in the first place, that a stop is fitted to prevent the flap from being raised higher than its position of maximum lift, and that the control is in some way interconnected with the throttle, so that the pilot's hand does not need to be moved from one control to

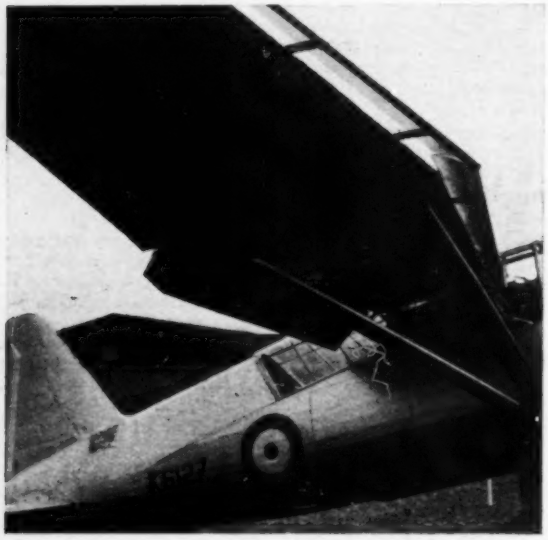
another. In the latter case the throttle lever might be used for "brake" operation, while the initial high-lift angle is given through a separate control. Before the take-off or approach, this master flap lever would be moved to place the flaps in the most efficient lift position, and thereafter the throttle lever would be used to control the rest of the movement. If the pilot saw that he was under-shooting he would move this lever, thus raising the flaps, and if, after this movement, he found that he was still tending to arrive short of the aerodrome boundary, any further movement would open up the engine.

In modern high-efficiency machines very high lift as well as drag is demanded of the auxiliary wing surfaces which make up what may be considered as a composite wing. Each one of the three parts of the present idea of a composite wing—the main lifting surface, the flaps and the slots—can only work in conjunction with the others since they are mutually interacting.

A Modern Example

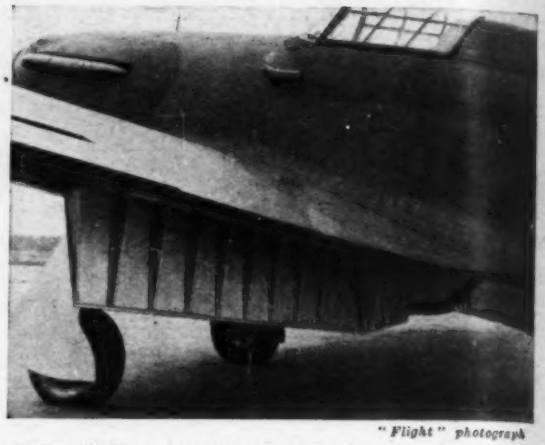
The best and most recent example of a machine in which slots and flaps have been utilised to the very best advantage is the Westland Lysander. This machine has a top speed of nearly 230 m.p.h., yet, with the slots open, the flaps down and the use of a fair amount of throttle, it will fly under full control at a speed probably lower than 55 m.p.h. In this machine the slotted flaps are interconnected with, and controlled by, the slots along the leading edge of the inner section of the wing. Consequently, the pilot does not need to worry about the operation of the flaps and is freed of a good deal of responsibility. He simply flies the machine as he wishes to fly it, and the slots and flaps do the rest, while the wing-tip slots serve throughout to provide adequate lateral control and stability at large angles of incidence, and, of course, at low speeds.

Both sets of slots in the Lysander are entirely automatic, but those at the root, which are used to operate the flaps, are designed to open at a rather lower speed, and to close again when an adequate margin has been obtained above the highest normal approach speed. With varying speeds the root slots and flaps open in such a way that, at the correct speeds for take-off, climb, glide-in, or landing, the flaps are pulled down to their most effective setting. As the machine is flown more slowly its characteristics change so that, within reason, it can fly even more slowly. To take an extreme example, when the control column is pulled right back the Lysander takes on and holds a tail-down attitude in which the glide is more or less in the nature of a sink. Thus, for emergency landings or in bad weather conditions, the machine can be brought down at the lowest possible forward speed while control is still retained. The vertical velocity involved in such circumstances is likely to be higher than that for which the undercarriage is designed, though in the ordinary way the throttle would be used to check the sink.



"Flight" photograph

Another successful application of high-lift principles—on the Westland Lysander, in which the inner slots operate the slotted flaps quite automatically, the angle so being adjusted to the speed.



"Flight" photograph

Plain split flaps—actually those on a Hawker Hurricane—shown in their position of maximum drag.

In many ways the technique of flying the Lysander is similar to that of flying an Autogiro. If, for instance, the pilot sees that he is under-shooting his field he eases the stick forward and increases the speed, which raises the flaps; if over-shooting his field he holds the stick back and reduces the speed, thus causing the flaps to be lowered.

Certainly serious concentration on the development of high-lift devices must be the next move in the improvement of aeroplanes, whether for civil or military purposes. Wing loadings have already gone beyond the limit at which they are safe with the lift and/or drag devices at present fitted to the majority of high-efficiency types. The Lysander is something of an exception, and one can only hope that it is the vanguard of new ideas in flying characteristics. It is not entirely necessary to suppose that in ten years' time the composite wing will be made up in the way described, but means must certainly be found of obtaining a higher performance and yet, at the same time, of improving the low-speed performance of aeroplanes.

The need for development on these lines is particularly obvious where civil machines are concerned, because unless something is done in the next year or two the travelling public will begin to lose the confidence which has been so slowly and imperfectly given to them.

University of London A.S. Dinner

WING COMMANDER A. H. HAMERSLEY, M.C., the chief instructor, and the instructors and members of the University of London Air Squadron, held their third annual dinner at the Rembrandt Hotel, Thurloe Place, London, on Friday last. It was a notable gathering, and the guests included: Sir Kingsley Wood, the Air Minister; Sir Robert Pickard, the Vice-Chancellor of the University; Air Marshall Sir W. G. S. Mitchell; Air Vice-Marshal W. L. Welsh, E. L. Gossage, and O. T. Boyd; Professor G. T. R. Hill, M.C., whose appointment as Dean of the Faculty of Engineering had been announced that morning; and several other dignitaries of the University and senior officers of the R.A.F. The latter included the two previous chief instructors of the squadron and also the chief instructors and other representatives of the sister squadrons of what one speaker called "the provincial Universities."

After the loyal toast, Wing Cdr. Hamersley proposed the health of the guests, and Sir Kingsley Wood replied with one of his typically eloquent speeches. Professor Hill was both witty and practical in proposing "The Squadron," and Mr. E. P. F. Magruder, in his reply, made perhaps the best speech which has ever been made by an undergraduate member of any of the University air squadrons on such an occasion. It was a most enjoyable evening.

PRIVATE FLYING

SOUTH AMERICAN Scene: This photograph was taken from one of the rear seats of a Messerschmitt Taifun (Me. 108) while the machine was flying over the famous Serra dos Orgãos near Rio de Janeiro. At the time a sea of clouds and mist covered practically the whole range.

Topics of the Day

This "A" Licence

WE have become so entirely used to the "A" licence (and the flying tests involved in its obtainment) that we are all rather inclined to forget how unreasonable and inadequate these tests are. I believe that they have remained unaltered since they were first instituted in or around 1910, when the business of making figures of eight and gliding without engine from a height of 2,000 feet or so was a serious, dangerous and even impossible one.

As it happens the "engine off" approach has remained useful as a meagre test of forced landing ability, and the figures of eight—if they are watched at all by the bored instructor—serve to show something of the pupil's powers of control co-ordination. But the barograph which is carried during these performances does not normally register the comparative small losses and gains in height which a bad series of eights would produce.

I know that when I went up to do mine (in the days when they took these things rather more seriously) I was advised to fly straight and level at 600ft. for at least five minutes in order that the line on the barograph chart might be long enough to be seen and admired. So far as I can remember the tests were done in the evening when there was not a bump in the sky, and when I came down, in a particularly proud state of mind, I found that both the instructor and one other pupil were indoors having an after-work drink.

Of course, the "A" licence does not really mean very much and before a pilot is allowed to go solo his instructor is, in any case, confident that his pupil is consistently fair in his flying. The possible failure, through examination nerves, to make a series of decent eights, or to get down on the aerodrome at the required spot without using the engine, is not taken too seriously. No one, least of all the pupil, imagines for long that a bare "A" licensee is free and safe to fly where and how he will. The licence merely gives a pilot lawful permission to fly further than three miles from the home aerodrome—after which, if he has not previously received any cross-country instruction, he promptly gets lost.

Modification Needed

ON the face of it, what is wanted, as in the case of a "B" licence, is an "Upper A," or, alternatively, an intermediate "Novice A." But, since no instructor allows a pupil to do as he or she pleases until at least fifty hours have been put in and some fairly rigorous forced landing and cross-country tests have been passed, it would probably be a good deal more logical merely to stiffen up the "A" syllabus to include these and other tests. In that case a preliminary licence might be issued, on the recommendation of a qualified instructor, to permit the pupil to fly elsewhere while still remaining under instruction. This would be similar to the car driver's "Learner" licence.

For the very good reason that different pilots have different standards of natural ability and intelligence, I do not think that a minimum hourage figure should be included in the new qualifications. A pupil who takes his flying seriously with an instructor who knows his business, may be quite good enough at the end of twenty hours, while another, whose instruction and practice flying have been spasmodic, might not be safe off the lead even at the end of fifty hours.

Nor should full aerobatic qualifications be in any way necessary, though the ability to carry out certain fairly simple manœuvres with accuracy might reasonably be demanded. Unless a pupil is being taught on a machine which is not to be spun, he is usually given a certain amount of spinning practice before going solo, and in other cases he is shown what happens at the stall and is encouraged to do gentle stalled turns at a safe height. Steep turns, too, form part of the normal training curriculum.

Reasonable Requirements

THE difficulty in thinking up a new syllabus for the "A" licence is not so much of deciding on the minimum as of the maximum requirements.

It is easy enough to think of ways in which the tests can be made so difficult that only a pilot of almost "B" licence standard can pass them. It should not be necessary, for instance, to know how to make accurate rumble approaches or absolutely accurate vertical turns, but one should be able to pull off a fairly consistent series of forced landing approaches in different circumstances, and be able to work out and fly a complicated cross-country flight in conditions when the visibility is not too good.

Since the degree of visibility day by day cannot be ordered, the testing difficulty in this case might be overcome by using some special form of map in which only the area immediately surrounding each turning point (or terminal aerodrome) is shown. The pupil would be expected to work out his courses according to the prevailing wind conditions and the accompanying instructor would, of course, carry a full set of maps himself—just in case he was afraid of getting lost.

Before reaching a stage of efficiency in which he might

Private Flying

expect to pass the test, a pupil would need to do from five to ten hours of cross-country instruction, and it is reasonable to suppose that during this period he would run into weather conditions which would provide some experience of what to do and what not to do in different weather circumstances. Intermediate landings would, of course, be made both during instruction and in the final tests. In the latter the pupil would also be expected to show his knowledge of airport signs, symbols and formalities.

As far as the *viva voce* examination is concerned, this would not need to be altered in basic principle, but the examiner would be expected to ask useful questions. And not about the number of lights which are hung at night on a dirigible airship which is out of control. The examination might, too, include a few questions covering practical dead-reckoning navigation (during which the pupil would be expected to show his ability to use some form of C.D.C. with reasonable speed and accuracy) as well as elementary meteorology—a subject about which very little is known even by the averagely competent and enthusiastic amateur.

Admittedly, when one runs into bad weather it does not help much to be able to plot a weather chart from a number of observations, nor to draw an accurate sectioned picture of a cold front. But a little knowledge in this case would not altogether be a dangerous thing, since it would give the amateur rather more respect for meteorological reports and weather conditions generally.

One day, when the Air Ministry and the R.Ae.C. have an hour or two to spare, somebody might get down to the business of formulating a new series of "A" licence demands which are more in keeping with present-day conditions. INDICATOR.

FROM the CLUBS and SCHOOLS

LONDON

THE flying time for last week amounted to 87 hours. Mr. J. H. Balmer and Miss L. Dove have completed the tests for their "A" licences.

IPSWICH

Another good week has been experienced and the flying total was 33½ hours.

THANET

Last week's flying total was 28 hours. Mr. K. Collinson made his first solo flight.

NORTH BRITISH

Over 22 hours were flown by C.A.G. members last week. Messrs. R. L. Whyman and F. W. White have gone solo.

EASTBOURNE

Owing to bad weather last week the club's flying time amounted to only 29 hours. Messrs. Dinnis, Hall-Hedley and Rees have gone solo.

BEDFORD

Fifteen C.A.G. "A" licences have now been obtained, while 26 members have reached the solo stage. A New Year party is being planned for January 1.

YORK AND LEEMING

Exceptionally bad weather last week reduced C.A.G. flying to 25 hours. The club's fifth annual ball will be held at Harrogate on February 24, 1939.

HYDERABAD

The total flying time for October was 12 hr. Mr. Syed Jaffer Ali has gone solo, and during the month a number of cross-country and charter flights were carried out.

YORKSHIRE

Fifty hours' flying time was recorded by the club last week, in spite of bad weather conditions. It is hoped that the new club house and hangar will be ready early next year.

READING

Since November 24 weather has been favourable and flying has been possible on every day. Miss Diana James has gone solo and Mr. C. Whitnell has completed his "A" licence tests.

PERTH

The promise of improved weather did not materialise during the first week of December, when only 18 hours' flying time was recorded. Mr. S. Prain made his first solo flight.

BENGAL

The club recorded 70 hr. flying time during the month of October. Mr. W. Hollenstein has joined as a new member, while Messrs. K. J. Thouless and Biren Roy have renewed their "A" licences.

PORTSMOUTH

Club members flew 12 hr. 10 min. last week, while 22 hr. 10 min. were flown by C.A.G. members. Ten C.A.G. members have qualified for their "A" licences and 41 have reached the solo stage.

NORTHAMPTON

During the Christmas period the club will be closed from December 24 to 27. A dance will be held in the clubhouse on December 30. New members include Mrs. M. Sarjeant, Miss V. M. Bird and Messrs. Mather and W. S. Gilbert.

JOHANNESBURG

During October the Johannesburg Light Plane Club flew 472 hours. One member obtained his "A" licence, two others—Messrs. E. C. Newborn and R. Knight—completed their "B" licence tests, and Messrs. P. E. Saunders, J. W. Meiring and G. Fries finished their instructors' courses. At the club dance on October 29 the year's trophies were presented, including miniatures of the Neal Trophy to Captain S. S. Halse and Mr. P. Hesselson for the most meritorious flights respectively during 1936 and 1937. Other winners were:—Bellin Trophy: J. A. Williams; Short Trophy: W. L. Grafton; and Baragwanath Trophy: J. A. Williams and W. L. Grafton.

WESTON

Twenty-one hours were flown last week by the Weston Aero Club, in spite of very bad weather.

YAPTON

During the first ten days of December C.A.G. members flew 42 hr. 5 min. Ten members are now flying solo, while two have passed their "A" licence tests. Club flying amounted to 10 hr. 5 min.

PLYMOUTH

Although the weather has been far from favourable, 34 hours were flown last week. This was mostly dual instruction, as the conditions were not suitable for solo flying by inexperienced pupils.

REDHILL

During the last fortnight the club's flying time amounted to 160 hr. 10 min. Mr. C. M. Small has gone solo, while six "A" licences have been granted to members. The club will be closed from December 24 to January 1 inclusive.

HANWORTH

Ninety-three hours were flown by the club last week. Messrs. J. Coxall, F. Flint, V. Stephens and A. Dunn have passed their "A" licence tests, while Messrs. H. Marshall, F. Passmore, C. Walker, P. Mayne and Mrs. K. Lett have gone solo.

SHOREHAM

High winds last week somewhat curtailed flying times. A C.A.G. member, Mr. E. S. Cleeves, has passed his "A" licence tests. The annual general meeting will be held on January 7 and will be followed by a New Year dinner and dance.

NEWCASTLE

The total flying time for last week amounted to 11 hr. 10 min. for club members and 39 hr. 35 min. for the C.A.G. Some 300 members of the latter body attended a talk by Maj. Alan Goodfellow last week. Messrs. E. E. Fail and S. Pollock have gone solo.

MARSHALL'S

The flying time for last week amounted to 99 hr. 50 min. Mr. K. Robertson and Mr. Creighton have joined as new members, while Mr. B. P. Wallis has joined the staff of instructors. Mr. N. Cannon, of the C.A.G., has gone solo, and Miss E. Roper has passed her "A" licence tests.

NORWICH

Better weather conditions prevailed last week and enabled ten members to fly. In the gliding section the nacelled Dagling was taken up to 900ft. off a car tow by two members. Another C.A.G. member has gone solo, while a lady member has passed her "A" licence tests.

ROMFORD

Weather conditions were quite favourable last week at Romford and 45 hours of dual instruction were given. Messrs. J. Windscheffel and B. R. Turner went solo, and Mr. A. J. Reid qualified for his "A" licence as a member of the C.A.G. There was a record attendance for the C.A.G. Dance held at Maylands.

EXETER

Owing to necessary modifications only one machine was available last week, during which the flying total was 12 hours. On December 4 the Exeter Aero Club won their first squash rackets' match of the season, when they beat Bristol Airport by 3 matches to 2. Capt. D. A. D. Young and Dr. A. Glen put up particularly good performances.

BROOKLANDS

The club will be closed from December 23 to January 2. Last week members flew 94 hours, while Messrs. R. Kahn, M. W. Colledge and Miss Diana Barnato went solo. The Brooklands, Lympne and Northampton Clubs are to combine in forming a Christmas good will flight to Shoreham on December 18 for lunch. Other club members will be welcomed provided due notice is given. Capt. R. W. Greenwood, Messrs. J. Machin, R. H. V. Saunders, J. Grierson and B. S. Smallman, have been given the rank of Flight Lieutenants in the Air Defence Cadet Corps, while Messrs. J. D. Firth, E. H. Fox and S. J. Graveley are to be Flying Officers.

SERVICE AVIATION

Royal Air Force and Official Announcements

R.A.F. Benevolent Fund

THE R.A.F. Benevolent Fund's fifth council meeting of the year was held on Wednesday of last week, with Lord Wakefield of Hythe in the chair.

The total expenditure on relief for the Council year ended December 1, 1938, amounts to £16,304, which is £2,280 more than the figure for 1937.

It was announced that the new building recently purchased by Lord Wakefield for the Fund at a cost of £3,000 was to be known as the "Wakefield Wing" of the Vanbrugh Castle School, which it adjoins, and that with this new wing the school would in future accommodate 67 sons of deceased airmen. It will be ready for occupation by next spring.

The Air Force List

THE December issue of the *Air Force List* has now been published. It can be purchased (price 4s.) from H.M. Stationery Office at the following addresses: Adastral House, Kingsway, London, W.C.2; 120, George Street, Edinburgh; 26, York Street, Manchester; 1, St. Andrew's Crescent, Cardiff; 80, Chichester Street, Belfast; or through any bookseller.

Flying Accidents

THE Air Ministry regrets to announce the following accidents:—Sgt. Raymond William Kingsley Clark (flying solo) lost his life in an accident which occurred at Walsgrave-on-Sowe on December 6 to an aircraft of No. 9 Elementary and Reserve Flying Training School, Coventry.

Cpl. John Robert Daniel (flying solo) is missing and believed to have lost his life in an accident which occurred at Chesil Bank Ranges on December 10 to an aircraft of No. 9 F.T.S.

THE AIR MINISTER studies a partly assembled Merlin during his visit last week to the Rolls-Royce works at Derby.

First German Carrier

HERR HITLER and Field Marshal Goering were present at Kiel when the first German aircraft carrier, *Graf Zeppelin*, was launched on December 8. The vessel has a displacement of 19,250 tons, and it is stated that it will carry 40 aircraft. The flying deck measures 750 by 80ft. The speed is given as 32 knots. A sister ship is under construction at Kiel.

Royal Air Force Gazette

Royal Air Force

General Duties Branch

The following Flying Officers are promoted to the rank of Flight Lieutenant on the dates stated:—L. W. Saben (Acting Flight Lieutenant) (September 16); A. R. Leggate (Acting Flight Lieutenant (October 16); W. W. Loxton (Acting Flight Lieutenant), N. F. Simpson (October 30); D. P. Frost (Acting Flight Lieutenant) (November 3).

The following Flying Officers are granted the acting rank of Flight Lieutenant on the dates stated:—J. W. S. Forbes (October 4); N. W. Wright (October 29); R. C. Love, G. W. C. Watson, M. V. Peters-Smith (November 16).

Medical Branch

The following Flight Lieutenants are granted permanent commissions in that rank (December 2):—L. MacK. Crooks, M.B., Ch.B., D. J. Sheehan, M.R.C.S., L.R.C.P., R. F. Wynroe, M.B., Ch.B., D.M.R.E. F/O. B G. Haynes, M.B., B.S., is promoted to the rank of Flight Lieutenant with effect from September 6 and with seniority of September 6, 1937; Flt. Lt. H. C. de B. Milne, M.R.C.S., L.R.C.P., is transferred to the Reserve Class D (December 2).

Dental Branch

F/O. F. C. W. Rudd, L.D.S., is promoted to the rank of Flight Lieutenant with effect from November 1 and with seniority of May 1.

Chaplains Branch

The Rev. N. Collinge is granted a short service commission with the relative rank of Squadron Leader (November 25).

Royal Air Force Reserve

RESERVE OF AIR FORCE OFFICERS

General Duties Branch

Flt. Lt. D. Hodson relinquishes his reserve commission on completion of service (March 3); Wing Cdr. T. B. Marson, M.B.E., relinquishes his reserve commission as Flight Lieutenant (Honorary Wing Commander) in Class C, on completion of service (October 3).

Auxiliary Air Force

General Duties Branch

No. 609 (WEST RIDING) (FIGHTER) SQUADRON.—F/O. (Honorary Flt. Lt.) Lord Lincoln is transferred to No. 616 (South Yorkshire) (Fighter) Squadron (November 1).

No. 616 (SOUTH YORKSHIRE) (FIGHTER) SQUADRON.—F/O. (Honorary Flt. Lt.) Lord Lincoln is promoted to the rank of Squadron Leader and appointed to the command of the Squadron (November 1).

Forthcoming Events

DECEMBER.

Thurs., 15th. **R.Ae.S. Yeovil Branch Lecture: "The Paris Aero Show," by W. E. W. Petter.**

Thurs., 15th. **R.Ae.S. Coventry Branch: "Aero Engine Carburation," by E. W. Knott, M.I.A.E., M.S.A.E.**

Thurs., 15th. **R.Ae.S. Portsmouth Branch Lecture: "Influence of Design on Engine Production," by L. H. Pomeroy, M.I.Mech.E., M.I.A.E.**

Thurs., 15th. **R.Ae.S. Lecture*: "Some Results from the Deutsche Forschungsanstalt für Segelflug Smoke Tunnel," by Herr A. Lippisch, A.F.R.Ae.S.**

Thurs., 15th. **D.H. Aeronautical Technical School: Reunion Dinner, London Aeroplane Club, 8 p.m.**

Tues., 20th. **R.Ae.S. Isle of Wight Branch: Debate.**

Tues., 20th. **R.Ae.S. Students' Section Lecture: "The Air Mail Scheme," by Gibson Pattison, F.S.S.**

JANUARY, 1939.

Wed., 4th. **R.U.S.I. Lecture: "Psychological Effects of Bombing," by Dr. E. B. Strauss, M.A., D.M. (Oxon.), M.R.C.P., Royal United Service Institution, Whitehall, 3 p.m.**

Thurs., 12th. **R.Ae.S. Yeovil Branch Lecture: "Retractable Undercarriages," by R. H. Bound.**

Thurs., 12th. **R.Ae.S. Portsmouth Branch Lecture: "Recent Progress in German Aircraft," by B. S. Shenstone, A.F.R.Ae.S.**

Fri., 13th. **Coventry R.A.F.V.R. Annual Supper Dance. Drill Hall, Coventry.**

FEBRUARY.

Wed.—Fri., 1st—3rd. **Aerodrome Owners' Association: Airports Conference and Exhibition.**

Fri., 24th. **York and Leeming Flying Club: Annual Ball, Harrogate.**

* This lecture takes place at 6.30 p.m., at the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1.

AIRSCREW DEVELOPMENT

A Review, with Special Reference to Variable-Pitch Designs

IT is a simple matter to trace the transitory stages of airscrew development from the paddle-like devices which flailed the air in Edwardian times to the constant-speed fully feathering three-bladers of to-day.

By 1909 airscrews were commonly of the hand-shaped wooden two-bladed type—a form which persists to-day for a variety of uses. Four-bladers, with the advantage of small diameter, were put to good account during the war period, but fell from favour during later years. The three-bladed variety came into its own comparatively recently as manufacturers perfected the technique of metal-blade production.

Typically, the construction of a wooden airscrew in the last twenty or twenty-five years has been based on the use of walnut, mahogany or, more recently, birch laminations or layers glued together to lessen the chances of warping.

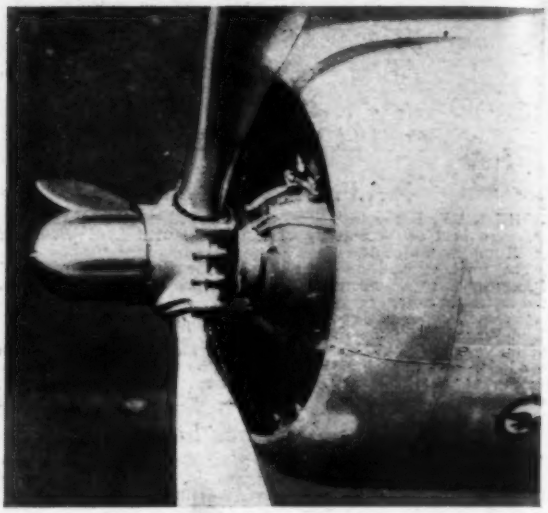
The advent of the practical metal airscrew was heralded in America by the introduction, something like fourteen years ago, of the Curtiss-Reed type. This was produced in two forms, both being solid from end to end, though one was made from a slab of duralumin, the blades being twisted to the required pitch. The later refined version was of forged duralumin. The licence for the Reed airscrew was acquired in this country by the Fairey Company, which turned out many hundreds of examples. The advantages claimed for the Fairey-Reed airscrew are economy of upkeep; elimination of warping troubles; and the ability to employ extremely fine blade-tip sections, permitting increased tip speeds.

Not long after the introduction of the Curtiss-Reed airscrew the Hamilton-Standard concern in America perfected an adjustable-pitch type with detachable metal blades. The term "adjustable" is here intended to denote the ability to vary the blade-setting on the ground. This characteristic was of very limited value, as one aspect of performance, *e.g.*, level speed, was still bound to be handicapped at the expense of another. One distinct advantage, however, was the ease with which the blade could be replaced.

These adjustable-pitch Hamiltons prepared the way for the Hamilton variable-pitch models, the blade angle of which could be changed in flight.

The original Hamilton-Standard two-position airscrew (which was soon taken up by the De Havilland Company, who now produce all types of Hamilton v.p. airscrews) had a highly beneficial effect on performance. By way of explanation let us consider performance under two headings—"take-off and climb" and "level flight." It is impossible with a fixed-pitch airscrew for the engine to develop its rated power, and for the airscrew to translate this power with the maximum of efficiency, under both these conditions, because the load on the engine is constantly varying with the speed and attitude of the aircraft.

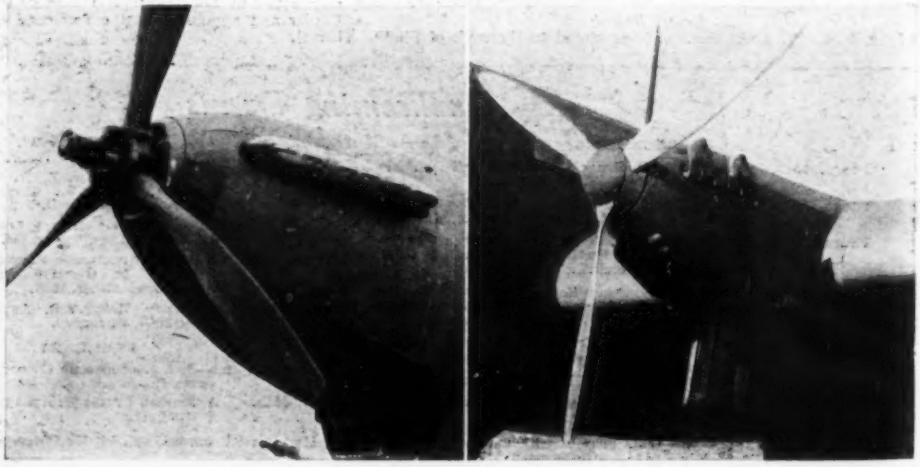
To put it simply, the fixed-pitch airscrew is always a compromise between the requirements for take-off, climb and level flight. The introduction of the two-pitch Hamilton meant that the engine could develop its rated power both for climb and level flight with a marked improvement in airscrew efficiency under both conditions. Supercharged engines, which had hitherto suffered badly at take-off, derived particular advantage, as witness the following figures for the Rolls-Royce Kestrel XVI fully supercharged unit operating with fixed pitch and variable pitch airscrews:—



A Hydromatic airscrew, the rights of which are held in this country by the De Havilland Company, as mounted on a Pratt and Whitney Twin Wasp.

	International Rating.			Take-off.		Nett dry Weight.
	Altitude in ft.	r.p.m.	b.h.p.	r.p.m.	b.h.p.	
Fixed pitch ...	11,000	2,600	690	2,225	670	955
Variable pitch ...	12,250	2,750	715	2,750	745	985

The two-position Hamilton operates on the hydraulic principle, using the engine lubricating-oil pressure to change into low pitch and centrifugal force of counterweights to change into high pitch. Stresses arising from centrifugal force are absorbed by the barrel and those due to torque are catered for by a component called the spider. In flight the blades tend to take up the high-pitch position due to the centrifugal action on the counterweights. The low-pitch setting is secured by admitting pressure oil to a cylinder which then moves along a fixed piston, and by means of a cam motion moves the blades to the low-pitch position against the pull of the counter-



On the left is the De Havilland variable-pitch three-blader (Hamilton licence) as fitted on the Rolls-Royce Merlin engine of the Fairey Battle. The right-hand view shows a fixed-pitch Fairey as used for the Kestrel engines of the Fairey Hendon.

weights. As soon as the pressure is removed the blades take up the high-pitch position and the oil in the cylinder is returned to the crankcase under the pull of the counterweights.

More recently the Hamilton and De Havilland concerns have built large numbers of constant-speed airscrews. These are similar to the two-pitch type, but embody a device by means of which the load on the engine is varied automatically by the airscrew, maintaining a constant speed and power output over a wide range of conditions, irrespective of the attitude of the aircraft in flight. This device may be likened to an infinitely variable gear box. An over-ride control enables the pilot to obtain maximum efficiency at all times. Advantages claimed for the constant-speed unit are fuel economy, reduction in engine wear and relief for the pilot. Briefly, the automatic control unit consists of a gear-type pump fed by oil from the engine and delivering to the airscrew a constant pressure of about 200 lb. per sq. in. Two engine-driven flyweights operate a piston valve admitting and releasing oil to or from the cylinder.

The very latest Hamilton development—and one which has been quickly taken up by the De Havilland concern—is the Hydromatic airscrew. This has been introduced to meet the demands for airscrew pitch ranges created by modern military types and by the increased speed ranges and ceilings of new commercial aircraft. It is capable of being fully feathered, *i.e.*, the chord of the blades may be set almost parallel to the line of flight—a factor of some importance in multi-engined aircraft should one power unit fail. The hub and blade mounting structure is similar to that used on previous Hamilton airscrews, but has been improved in a few respects.

Even after the two-position Hamilton had been put into general service in America many technicians still regarded the device with little enthusiasm. In *Flight* of June 6, 1935, one finds a volume of correspondence from designers discussing the relative merits of variable-pitch airscrews, two-speed reduction gears and high ground boosting for take-off. By that time it was generally agreed that the v.p. airscrew had come to stay. One of the earliest manifestations of the capabilities of the "v.p. prop." was the success of the De Havilland Comet long-distance racing machine powered by two 225 h.p. Gipsy Six engines fitted with v.p. airscrews. This machine was able to lift over the screen a total load of 5,550 lb.—at least, 1,000 lb. more than could have been handled with fixed-pitch airscrews.

Early V.P. Limitations

The Comet was originally fitted with French Ratier airscrews, the De Havilland Company at that time not being in production with a suitable airscrew of their own. This model of the Ratier did not permit full control of the pitch during flight. The pilot could change from fine to coarse pitch whenever he wished, but when once set to coarse position it was not possible to change back to fine. Overshooting on a landing was, in consequence, distinctly unpleasant, due to the slow acceleration.

Since that date the Ratier company has developed a number of outstandingly interesting airscrews. One has been evolved for use with the French *moteurs canon* and provides for small explosive shells to be fired through the airscrew hub. The secret is a small windmill operating the pitch-changing mechanism; when the speed of the windmill drops below the airscrew speed the pitch changes into the fine position and vice versa. Thus on climb the pitch changes down, and in level flight makes the reverse movement.

The simple windmill system of operation is also employed for the new Argus airscrew.

A type which seems destined for a useful future, not only in America, but in this country (the licence having been secured by Rotol) is the electrically operated fully feathering Curtiss. An outstanding advantage of the electrically operated type is the ability to be used either as a constant-speed or a selective manually controlled type in the same installation. The manual control allows any blade angle between the low-pitch limit and the feathered angle to be obtained and maintained independently of engine conditions. Pitch change is effected by a small series-wound reversible direct-current electric motor, operating through a two-stage planetary speed-reduction unit to a bevel power gear which engages a bevel gear fixed to the root of each blade.

An example of the latest type of Fairey variable-pitch airscrew, preliminary details of which are given in the accompanying article.

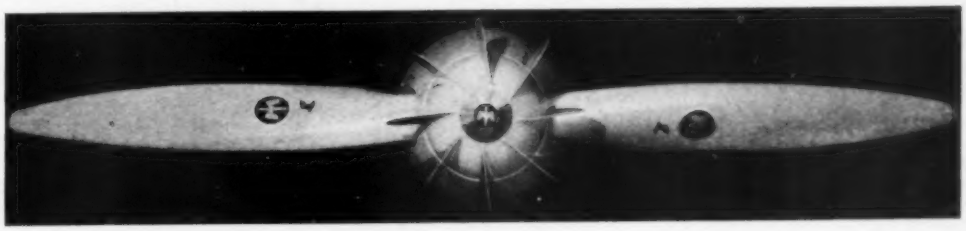
Electrical operation is also employed on the German V.D.M. design; this likewise is capable of being fully feathered.

Although the Rotol concern has the licence for the electrically operated Curtiss, and will, in fact, shortly be producing airscrews of this type, the company sets great store by the hydraulically operated units of its own design. Fully feathering and non-feathering designs are available; in either case the airscrew comprises essentially an hydraulic cylinder to which the blades are connected by operating pins or links and a fixed piston carried on a sleeve member extending through the cylinder. Pressure oil from the engine, controlled by an engine-driven governor unit, actuates the cylinder and varies the pitch of the blades.

Apart from the Rotols, we have under development in this country a number of Fairey variable-pitch designs. A typical unit for an engine of 1,000/1,200 h.p. (12ft. 6in. in diameter) weighs 360 lb. with duralumin blades; 320 lb. with magnesium blades and 300 lb. with wooden blades. The blades have a range of 360 deg. Minimum and maximum positions are controlled by stops which can be reset without removing the airscrew from the engine. Attractive characteristics are the main operating unit, which can be used for airscrews of engines from 700 h.p. to 1,200 h.p.; the ability to remove the blades complete with their bearings as units; and the fact that the airscrew can be assembled by one mechanic and an assistant without the use of special tools or equipment in about three hours.

The French Gnome-Rhône airscrew is of interest chiefly because it employs compressed air. To adjust the pitch the pilot operates a lever and admits air through a valve, driving a piston and moving the airscrew blades. When the desired pitch is reached the lever is released and the pneumatic drive immediately cut off. The makers emphasise that the pilot's movements should be carried out in a decided manner and without hesitation; he might be tempted, they explain, to reach the best pitch by tentative moves or to operate the controls by jerky touches which would be unfavourable to the proper mechanical working of the airscrew.

Although constant speed is generally associated with the larger types of airscrew this feature is now available for the private owner of even the smallest aircraft types. The airscrew concerned is the strikingly unorthodox single-blade American

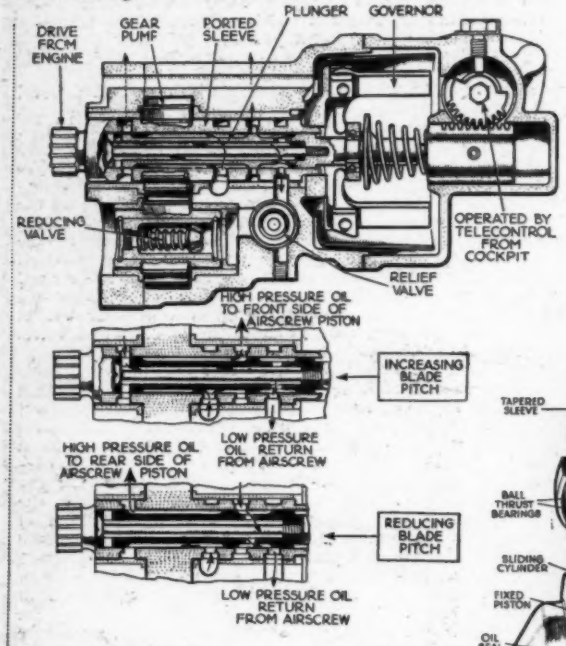


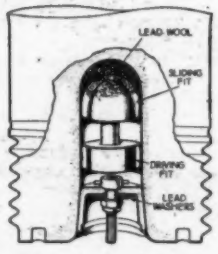
A system of vanes is used to control the pitch on a new type of Argus airscrew developed in Germany.

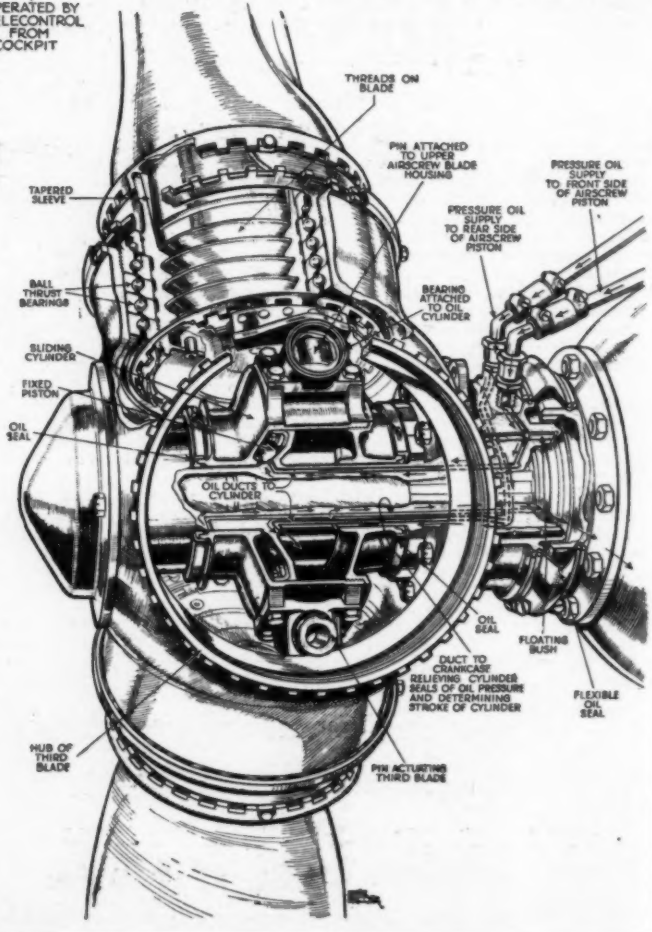
Everel. In this design the tip of the blade moves about three inches in a forward or rearward direction, at the same time twisting to fine or coarse pitch. An equilibrium is set up between (a) the force on the blade due to thrust tending to produce the fine-pitch position; and (b) centrifugal force to the hub assembly about the pivot tending to produce coarse pitch. In construction the airscrew is fairly normal, being of the cemented laminar wooden type, but having a counterweight. The De Lavaud airscrew works on a similar principle.

The reversible-pitch airscrew has for some time been the subject of intensive research. The Hamilton and Curtiss concerns in America are said to be experimenting on behalf of the U.S. Navy, and in Italy the test pilot, Mario Stoppani, lately demonstrated a device of this type on a Cant Z.506 seaplane. Apart from its braking effect this form of airscrew is of particular value on flying boats and seaplanes, greatly simplifying handling on the water.

Although the variable-pitch airscrew is usually associated with metal blades, there seems to be a future for the use of wooden blades in this connection. Of particular note are the Schwarz patented wooden detachable blades made in this country by the Airscrew Company, Ltd., of Weybridge. The low weight of these blades is said to reduce very considerably the centrifugal forces on the bearings. Moreover, all forces exerted by the blade are taken up by a single bearing in which a novel method of elastic pre-loading is employed to obviate alternating stresses which are highly undesirable in ball or roller bearings.






THREADS ON BLADE
PIN ATTACHED TO UPPER AIRSCREW BLADE HOUSING
PRESSURE OIL SUPPLY TO FRONT SIDE OF AIRSCREW PISTON
TAPERED SLEEVE
PRESSURE OIL SUPPLY TO REAR SIDE OF AIRSCREW PISTON
BALL THRUST BEARINGS
BEARING ATTACHED TO OIL CYLINDER
SLIDING CYLINDER
FIXED PISTON
OIL SEAL
OIL DUCTS TO CYLINDER
OIL SEAL
FLOATING BUSH
DUCT TO CRANKCASE RELIEVING CYLINDER SEALS OF OIL PRESSURE AND DETERMINING STROKE OF CYLINDER
FLEXIBLE OIL SEAL
HUB OF THIRD BLADE
PIN ACTUATING THIRD BLADE

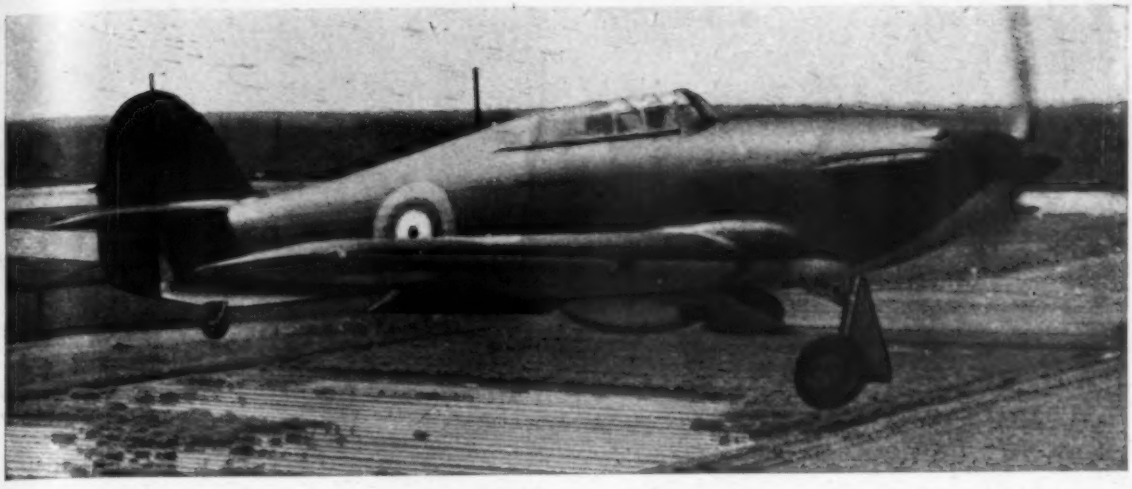
Some specially prepared and self-explanatory drawings showing features of the Rotol constant-speed (non-feathering) airscrew as used for the Pegasus engines of the record-breaking Vickers Wellesleys. It should be pointed out that in the right-hand view one blade has been removed to show the internal arrangement.

The Schwarz process of airscrew protection consists in covering the airscrew with a film of cellulose acetate 1 mm. thick. The leading edge is covered with a thin strip of cellulose material. Over this—and the whole of the blade and boss—is a layer of fabric or high-tensile steel gauze. The leading edge is covered with a strip of specially woven phosphor-bronze wire gauze to which is sweated a nose-piece of brass. After being thus prepared the airscrew is covered with a sheet of cellulose material applied in a plastic condition.

Under licence from the German Heine Company, Jablo, Ltd. are manufacturing a type of airscrew in which a kind of synthetic resin is used for cementing the laminations together. Another kind of resin is sprayed over the surface and, while this is still "tacky," a steel gauze, covering the outer three-quarters of the blade, is applied. When the synthetic resin has set a narrow strip of brass is soldered to the gauze along the leading edge and the whole is covered with a coat of self-hardening glaze.

A third process, the licence for which is held by Hordern-Richmond Aircraft, has been introduced by the B.T.H. concern. This consists of a synthetic resin-impregnated fabric covering offering a very high resistance to abrasion and tending to damp out vibration and flutter. Considering that the future of the airscrew lies with a detachable blade, Hordern-Richmond are devoting their attention to development of suitable material, and it has lately been announced that experimental work has been carried out with laminated wood, compressed and bonded with various plastic materials under the company's own patents.

The airscrew brake, developed chiefly in America and on the Continent, is represented in this country by the Avimo type. In a design of a brake of this sort it is necessary to avoid any mechanical arrangement which would result in lateral or longitudinal strain on the engine or the airscrew arising from the application of the brake. Consequently, a radial brake was adopted. There are two brake bands, set off at 180 deg., this arrangement obviating any possibility of strain on the crankshaft. The control pump is of the piston type and is worked by a lever in the cockpit.



The inwardly retracting undercarriage of a Hawker Hurricane being tucked away just after taking off from Brooklands.

UNDERCARRIAGES

An Outline of Modern Tendencies : The Tricycle : Persistence of Fixed Gear

THE dividing line between aircraft on which the retractable undercarriage, with its attendant weight and complication, is warranted and those which would benefit more from the use of a fixed landing gear is ill-defined. Retractable wheels have been applied to all types of landplane and amphibian except the most diminutive runabouts, though the popularity of the smaller private-owner machines with such gear has by no means been established. In this connection it will be instructive to follow the progress of the little Bellanca lately introduced into America. Our own B.A. Eagle, it may be recalled, although originally built with a retractable undercarriage, was subsequently offered with a fixed gear as an alternative.

There are still certain types of military machine for which the retractable undercarriage is considered undesirable—army co-operation machines, as typified by the Westland Lysander, and what the French call *avions de travaille*, or machines which are designed to do a hard job of work when operating from advanced aerodromes.

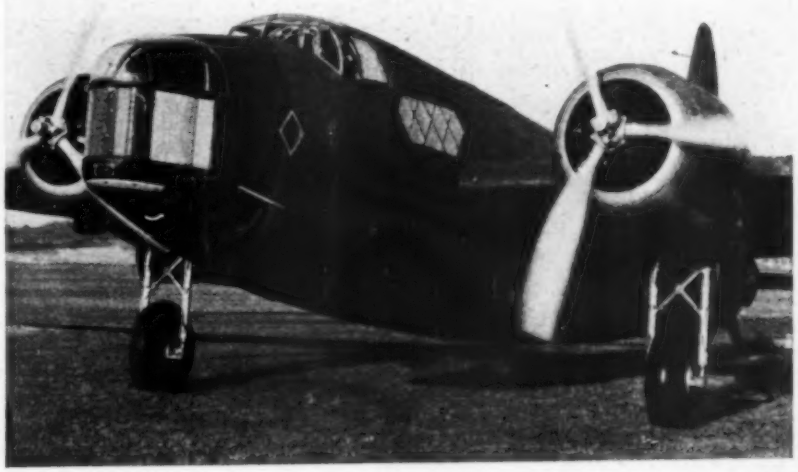
The pronounced trend toward so-called tricycle undercarriages introduced a new set of problems, though none which seem likely to prejudice to any marked extent the tricycle's chance of widespread, if not universal, adoption.

The decision of the Douglas Company to specify a gear of this type for the 60,000 lb. D.C.4 was, to say the least, courageous. The Douglas lead is being followed in this respect in the new Fairey four-engined transport under construction in this country. The advantages of the tricycle undercarriage as applied particularly to the smaller types of aircraft—easier landing, improved vision, the possibility of faster taxying and turning, etc.—have been discussed on a number of occasions in *Flight*. As a result of experience with a special S.T.25, General Aircraft are specifying a tricycle for the production type Cygnet two-seater. Benefits to be derived by the larger transport aircraft include increased passenger comfort, particularly in sleeper aircraft at night, and improved safety during blind landings. The Douglas Company also stresses the quicker take-off.

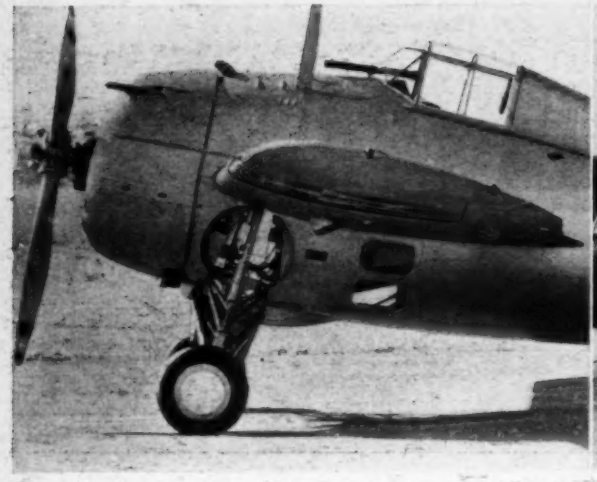
The space available for these notes can be better devoted to an examination of the later developments in design technique rather than to a résumé of the features of conventional fixed undercarriages as applied to the majority of private-owner aircraft, elementary trainers, and most of the older commercial and military designs.

When a fixed gear is specified for a modern design it is almost without exception of the cantilever type, very carefully faired. The first notable departure in this country was the application of the single-strut gear and Dowty internally sprung wheels to the Gloster Gladiator fighter. These same wheels also figure in the undercarriage of the Westland Lysander which, however, is of particular interest in that the essential component is a continuous hollow extrusion of aluminium alloy bent more or less into horseshoe form. The wheel fairings are used to accommodate the landing lights and fixed machine guns.

Retractable gears may be broadly divided into mechanically operated types with manual control; similar gear, but with electrical operation; and the hydraulic variety, which is dependent for its actuation on an engine-driven pump. Standardisation of components is, of course, a matter of extreme difficulty.



One of the neatest large undercarriages yet seen—that of the Vickers Wellington twin-engined bomber.



On the new Grumman monoplane fighter for the American Navy the wheels retract into the corpulent fuselage.

Unfortunate external fairings for the undercarriage characterise the Seversky pursuit used by the U.S. Army.

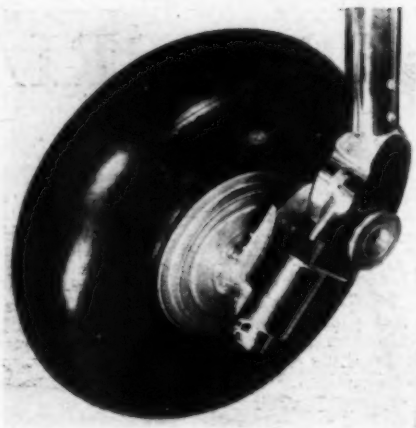
Despite the disadvantages of slow and somewhat tiresome retraction the mechanical type has a good deal to recommend it, notably the dependability and comparative simplicity. Electrical operation saves a good deal of time and effort, though it entails the provision of automatic switches to cut off the power when the wheels are fully retracted. The hydraulic system has been developed in this country to a very advanced stage, and is doing excellent work on aircraft up to the size of the 49,000 lb. Armstrong-Whitworth Ensign transport. Frequently the hydraulic retraction of an undercarriage depends on the same operating system as flaps, gun turrets, etc. In view of the fact that on many modern machines, particularly of the low-wing type, the undercarriage is not visible to the pilot, a system of visual dashboard indicators is supplied. The strident note of a horn mounted close by his ear often reminds the pilot that he is throttling back his engines with undercarriage raised.

On the majority of multi-engined aeroplanes the wheels retract into the engine nacelles, though this is not always the case, as witness the De Havilland Albatross. In this design the wheels fold inwardly and lie in the bottom of the fuselage. Although from many points of view it is desirable to keep the wheels in the line of flight, this is frequently impracticable due to the nature of the wing construction or the presence of tanks or military equipment. In consequence we find many of our new military machines with wheels which retract inwardly (*e.g.*, the Hurricane and Wellesley) or outwardly (Spitfire and Skua). If complete retraction is desired and the shallowness of the wing section or the diameter of the wheel does not permit it, it is sometimes found expedient to twist the wheel through 90 deg. during retraction as on the Miles Kestrel Trainer, the Vought dive bomber, and the new S.A.B.C.A. two-seater fighter.

A line of development which has been pursued in America is the retraction of wheels into the fuselage of a biplane or a mid-wing monoplane. Naval aircraft built on these lines by the Grumman and Curtiss concerns have not only benefited in the matter of performance, but have been assured of comparatively safe "ditching" characteristics.

The most advanced designs these days feature a retractable tail wheel, a fine example being that on the Handley Page Hampden.

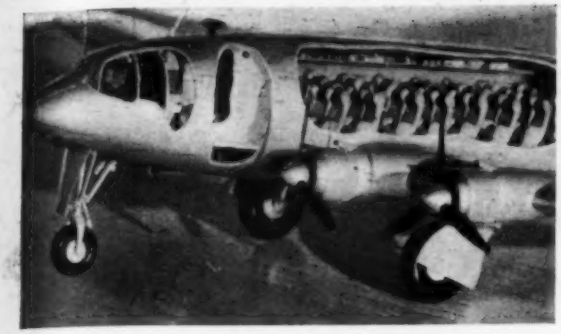
The pre-eminence of Great Britain in the design of undercarriage systems and components (particularly gratifying in view of our hesitancy in adopting the retractable undercarriage) warrants a more detailed study of some of the very newest proprietary developments.



The new Dowty wheel with built-in shock absorber.

The newest of these is the Dowty wheel with built-in oleo-pneumatic shock-absorber and cantilever mounting on a single strut. The makers claim smoother taxying and more pleasant take-off and landing characteristics and the possibility of standardisation. This wheel is a development of the high-pressure internally sprung type as fitted on the Gladiator and the Lysander. It is said that a wheel travel as great as 18 inches can be provided, setting up new possibilities in the development of tricycle undercarriages.

The business end of the Douglas D.C.4 monoplane, which has the largest tricycle undercarriage in the world.



The forward portion of the model of the new Fairey four-engined transport which will have a nose wheel of substantial proportions.

New developments in train at the Leamington works of the Lockheed concern are of special interest in view of their possibilities in connection with tricycle undercarriages. Two new features have been introduced in shock-absorber strut design which, if required, can be incorporated in the same unit, giving a strut particularly suitable for nose-wheel application, and one which may also be employed in tail-wheel units for undercarriages of orthodox design. First, there is a self-centring mechanism which is operative throughout the whole of the stroke, and with which is combined, in such a way that it can be incorporated within the strut itself, an externally adjustable hydraulic device to provide rotational damping against "shimmy."

A Contracting Strut

Secondly, in view of the limited space available for stowing a leg when retracted, a contracting strut has been developed, in which the hydraulic retraction system is connected to the strut in such a way that full closure of the strut is produced automatically before retraction commences, and vice versa. When the strut is in the landing position and fully extended, it functions as a normal "Airdraulic" shock-absorber.

Two types of accumulator system have been developed, both of which can be easily included in the standard Lockheed layout.

The first, for high-pressure services, makes use of a hydraulic cut-out valve of simple design and proved reliability which by-passes the flow to the accumulators when they become fully charged.

The second, for low-pressure systems, employs a restriction in the normal return from the selector valve which maintains the system at a pressure sufficient to charge the accumulators through non-return valves.

As in some cases the full output of a hydraulic system may produce an undesirably high speed of operation of certain services, a valve has been developed which can control the delivery of such services within close limits, irrespective of the speed of flow and pressure of the supply and load on the service.

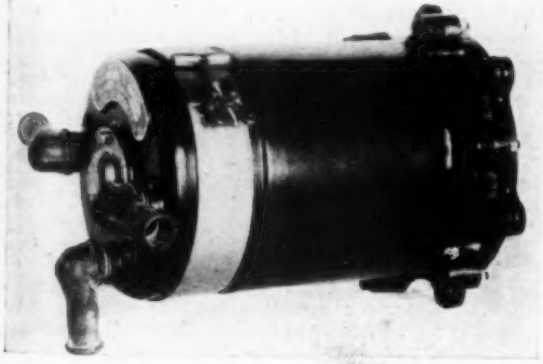
Individual lines of undercarriage development being pursued in this country are exemplified by the Maclaren "crabbing" gear and the Eugster (British Landing Gears, Ltd.) undercarriage. The Eugster may be regarded as a reversal of the normal tricycle layout, and shows up to particular advantage on tractor aircraft.

Reference to float undercarriages has so far been omitted. In this country they are confined almost entirely to machines of the Fleet Air Arm and to Service types operating from coastal bases.

Indications are that our manufacturers still favour the twin-float layout rather than the single central float with auxiliary wing floats.

The Supermarine Walrus amphibian exemplifies the application of a retractable land undercarriage (also used for beaching) on a marine aircraft. The wheels are raised into the wings.

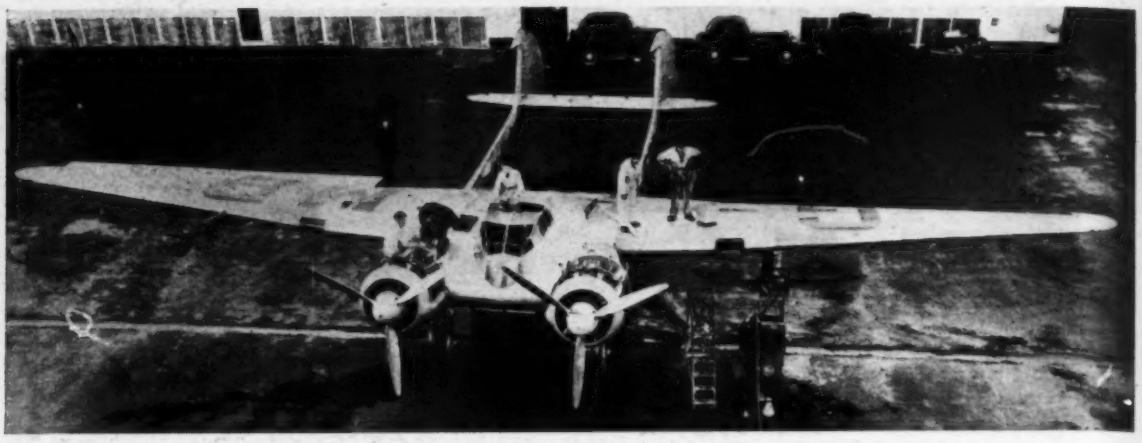
Showing how the retracted wheels of the D.H. Don are housed in fairings behind the intakes for the cooling air.



A Rotax motor used for retracting the undercarriages of large landplanes. The speed is about 6,750 r.p.m. and the weight 16¾ lb.

The largest retractable undercarriage unit in the world, as fitted to the Armstrong Whitworth Ensign transport used by Imperial Airways.

COMMERCIAL AVIATION



AERODYNAMIC ACCOMMODATION: The first of the new British Burnellis emerges from the Cunliffe-Owen Aircraft shops at Southampton for test flights. Bristol Perseus XIVC sleeve-valve engines, giving 900 h.p. each for take-off, are fitted. Among the new features is the control-cabin superstructure, which gives a good view abeam.

THE WEEK AT CROYDON

"A. Viator" on Christmas Mails, "Frobisher's" Attack of Gout, and the Airport's Firefighting Arrangements

THE all-up air mail scheme seems to be doing as well as can be expected, considering that a wicked, wicked public will not post early for Christmas.

Pig-headedly, the public remarks that if an air mail scheme does not give the advantage of later last-minute posting, then it just doesn't want the P.M.G.'s Christmas pudding.

If I want to send a postcard to Africa—to Lulu the Zulu, for example—or to remit a remittance to the family remittance man in Australia, and I have to post same three months before Yuletide, I may as well hire a Yarmouth hoy and deliver the goods personally, or else borrow an empty bottle from a friend who uses such things and set my greetings adrift therein along the course of any good, reliable easterly current.

With whatever Christmas mail a miserly public is not withholding, fully loaded flying boats are plying to and fro between Southampton and the Empire so fast and so frequently, that nary a barnacle can fasten on to a hull. (This, in passing, raises a natural history query. Will Nature fit future generations of barnacles—barnacles are unpleasantly pale and naked at the moment—with little fur coats so that they can ride through the air with the greatest of ease?

Now, so far as I can make out, every available aeroplane, including a Swissair Douglas sub-chartered to Imperial Airways, is dashing to and fro on the air mail racket.

Last Sunday nine machines with 10½ tons of mail set off, including the Ensign class *Egeria*. *Elsinore*, the sister ship, left last Monday, and *Mercury* also made another non-stop trip, Southampton to Alexandria.

Heracles went East with mails on Friday of last week, and those who say that all these are mails for Christmas, 1939, are low fellows of the baser sort.

Frobisher startled Croydon one day last week by appearing over the Airport with one leg of the undercarriage half up and half down. There was considerable circling whilst instructions and advice were passed to the pilot, Capt. Oliver, by the Company.

I must record my admiration for the very complete and well-thought-out precautions taken, in consultation with Imperials, no doubt, by the Airport authorities. There was a real fire brigade, all red and gold and brass polish, and yards and yards of hose-pipe all laid out across the Airport in such a way that the quickest use could be made, if necessary, of the business end thereof. There was a small fleet of six-seater limousines ready to dash out and collect passengers—a quicker scheme than using a big bus. And as the machine made its final wide circuit four or five ghost-like figures were to be seen creeping across the tarmac in the crepuscle (which came on about then, and is not, as you are thinking, a disease, but just dusk). They were men in asbestos suits complete with peaked hoods. As *Frobisher* came in to land, a pretty fast ambulance made a racing start from the tarmac, and ran, as you might say, alongside the landing aeroplane.

Happily, as a Pressman said in not altogether sincere accents, all this was unnecessary, for *Frobisher* landed lightly and easily on as sound a pair of legs as you ever saw in the front row of the chorus.

Something in the way of a remarkably fine job of work had been performed by the flight-engineer, who, finding *Frobisher's* gout did not yield to electrical treatment or hand massage, decided on a minor operation, and to this end had taken up some of the floorboards.

By the way, referring back to the completeness of the Air Ministry arrangements on this occasion, and the gents' asbestos suitings in particular, this is a refreshing change since the days when there was only a single left-hand asbestos glove about the place and when, in the event of fire, its official wearer was not only a right-handed man, but invariably away at his tea into the bargain. Moreover, there is every reason to believe that the water would now come out of the hose nozzle, instead of rushing violently backwards, thus flushing the drains unexpectedly into the main road.

H.R.H. the Duke of Kent flew from Croydon by K.L.M. to Hamburg and thence by D.D.L. to Copenhagen on December 5 on his way to Oslo to attend the funeral of H.M. Queen Maud of Norway. He returned on the Friday.

On December 6 a special K.L.M. Douglas D.C.3 left Amsterdam for Pretoria on a good will flight in connection with the "Voortrekker" celebrations. Over a month back a caravan of ox-wagons started from Capetown in exact imitation of the great trek of the Boers one hundred years ago, and they will reach Pretoria about the same time as the K.L.M. machine.

The Latest Q.6

THE first of the Percival Q.6s with a retractable undercarriage was delivered to Air Taxis during last week-end.

Full Control

WITH the increase in the number of D/F stations which are available in the British Isles it has now become possible to divide the country into further communication areas in addition to those which have previously been officially recognised.

There are actually fifteen of these areas. At the moment one of them, covering the extreme south-west of England, is without facilities as the D/F station promised for Exeter is not yet available. The other area stations are at Bristol (Whitchurch), Croydon, Heston, Hull (Hedon), Inverness, Jersey, Kirkwall, Manchester (Barton), Newcastle (Woolsington), Newtownards, Portsmouth, Renfrew, Sollas and Sumburgh.

The suggestion put forward in another *Notice to Airmen* (No. 279), that pilots of machines with radio equipment should advise the control of their flight plan looks rather like the thin edge of a wedge. Eventually, and quite obviously, it will be necessary for such plans to be worked out before all transport runs and rigidly adhered to. Only so will the control officers, as traffic increases, be able to keep track of all the different machines in the busy areas, and it seems that eventually even the private owner and charter pilot will also have to submit such a plan in the interests both of their own and others' safety.

The information required in the flight plan which is normally worked out by airline pilots in the United States includes both the exact route to be followed and the height to be flown, after the pilot and control officer have made a thorough study of meteorological conditions and decided on the best cruising altitude in the circumstances.

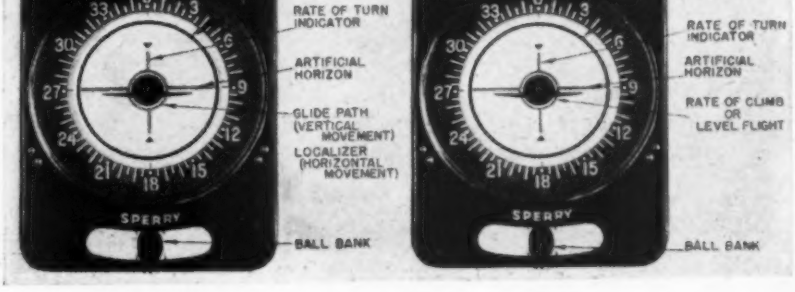
All-in-one

THE American Sperry Company has recently produced a special blind-flying and blind-approach instrument in which as many as eight gyroscopic and other indications are given on a single dial.

In the ordinary way, when being used for instrument flying, five different indications are provided, these being: direction (by means of a gyro), level (by means of an artificial horizon), rate of turn, natural bank (from a ball-type lateral level), and cruising altitude for a predetermined height. Fore and aft and lateral level with the turn indications are all given on the centre dial by a cruciform "background," which is lined up against the conventional miniature aeroplane. The directional indications are given against a 180-degree verge ring on the periphery of the dial. This is an interesting change from the more usual directional gyro layout in which the directional figures are marked on the rotating drum which moves against a mark on a small window. The centre of the cruciform "background" is made up of a circle, which gives the preselected cruising altitude indication.

By the movement of a selector switch three more indications are given for occasions when the instrument is being used during a blind approach. The normal readings are as before, except that the circular cruising altitude indicator becomes, in effect, a glide path indicator, the circle being pre-set to give the correct approach angle when it is registering with the fuselage of the miniature aeroplane. In addition, a horizontal movement of this circle in relation to the miniature aeroplane gives the machine's lateral position to the approach beam. There is a red-light stall warning, as well as a green light to give marker beacon indications.

The instrument is known as the Flightray, and the only missing information is that of height through the medium of a sensitive altimeter pre-set for the prevailing barometric pressure.



The Sperry Flightray as used for blind-approach work (left) and for normal instrument flying. The new type of directional gyro indication is interesting; it is arranged in this way so that it shall be in keeping with the other indications, which are explained in the paragraph above.

Using the Composite

MERCURY, after being separated from *Maia* above Southampton Water at four o'clock on the afternoon of November 29, reached Alexandria non-stop and according to schedule on the first of the series of special flights which this machine is making while carrying Christmas mail loads. The machine on this occasion carried more than a ton of mails in addition to the fuel necessary to make the flight non-stop with a reasonable reserve for unexpected contingencies. The trip was completed in a matter of 14½ hours, giving an average speed, for the 2,200 miles, of 152 m.p.h. Capt. D. C. T. Bennett, the pilot, was assisted by A. J. Coster—who made the Atlantic flight earlier this year with him—and by D. Munro.

Although the flight was made in the ordinary course of events, it was interesting in that it showed conclusively that the composite is very much a commercial proposition. Another flight was made last week-end.

Berlin-Tokyo

ONCE again the Focke-Wulf Condor transport has shown its capabilities. It will be remembered that earlier this year one of this type flew non-stop from Berlin to New York, and now a Condor has flown from Berlin to Tokyo in a little over forty-six hours to make the fastest flight ever accomplished between Europe and Japan. Three intermediate landings were made and the machine carried a crew of five and a passenger. The distance is approximately 8,500 miles, and the terminal to terminal ground speed works out at the somewhat phenomenal figure of 184 m.p.h. After leaving Tokyo a few days later the Condor was forced down in the sea near a Philippine beach—luckily without loss of life.

This unofficial record flight may be taken as being one of the preliminaries in D.L.H.'s desire to develop a through service between Berlin and Tokyo. Already there is a weekly service between Berlin and Kabul, passing through Athens, Baghdad and Teheran. It will be remembered that D.L.H. have a capital interest in China's Eurasia Aviation.

Guidance at Croydon

NOTWITHSTANDING the various devices which have been introduced from time to time to provide final assistance for pilots during an approach to an airport in conditions of bad visibility, there is still a great deal to be said for the good old paraffin flare-path.

Such a path, in various forms, is used at a number of airports, notably at Bromma, Stockholm, where sodium-vapour lamps are used to bring the pilot in over the last quarter of a mile before reaching the actual runway boundary.

Since last Friday a somewhat similar arrangement has been in use at Croydon, though in this case the flare-path is laid out on the aerodrome itself. It will be used at night when the visibility is less than 1 km., and by day when the visibility is less than ½ km.—*i.e.*, when machines are necessarily landing along the bad visibility runway, which is indicated by a chalk line. The flares are spaced at intervals of 25 yards, the first being 100 yards inside the boundary. The whole length of the path is approximately 600 yards.

Although what are known as the Croydon neon fog lights (consisting of a series of green and red flush lighting strips) is not on the present blind-approach line, pilots find them very useful when landing at night both in good and bad visibility. In fact, the whole tendency nowadays is for pilots to prefer the flare-path type of illumination rather than the floodlight, and at Ringway (Manchester) a new system of flush runway lights is being installed for use in one direction.

HERE and THERE

Record Problem : Mr. H. O. Short and Expansion Profits : Tyneside Steel Firms Co-operate

The Wellesley Record: A Poser for the F.A.I.

A PROBLEM, unprecedented in Great Britain, concerning homologation of world's air records will be faced by the Royal Aero Club in the course of the next few days when the sealed barographs carried in the three Vickers Wellesleys on their long-distance flight reach London.

One machine landed at Koepang, a distance of 10,715.448 km. (6,658.279 statute miles), and the other two landed at Port Darwin, a distance of 11,520.421 km. (7,158.467 statute miles) from their start at Ismailia.

It is clear that the first machine held the world's straight-line distance record for a few hours, but the problem is how to distribute the honour between the two other machines. They arrived in formation over Darwin aerodrome, and the question which will have to be decided by the Fédération Aéronautique Internationale is—do both machines hold the record or is the record held only by the leader of the formation?

To-night's R.Ae.S. Lecture

TO-NIGHT, December 15th, Herr Lippisch will deliver his R.Ae.S. lecture on the smoke-tunnel results of the *Deutsche Forschungsanstalt für Segelflug*. The lecture will be illustrated by a slow-motion film.

Herr Lippisch has obtained remarkabile results, some of which will be shown for the first time in this country. The film begins by showing the formation of the Karman Street and the cause of the periodic detachment of the vortices, and the lag of the stalling effect occurring when the incidence is suddenly increased. Herr Lippisch shows the outstanding importance of this lag and how with a rotor wing it is possible to maintain lift up to incidences of nearly 90 deg. The film demonstrates the importance of understanding the flow over flexible wings and how the elastic wing enables the stall to be postponed at very high angles of incidence.

The lecture will be delivered at 6.30 p.m. in the lecture hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.1. Visitors will be admitted to the lecture by ticket only, obtainable through a member of the R.Ae.S.

A Forum Club Occasion

THE ladies of the Forum Club take serious subjects in a serious manner. There is an aviation section of the club, and on Tuesday of last week a dinner and reception were held in the club rooms to mark the interest of this section in "Civil, Imperial, Military, and Exploratory Aviation." A large and distinguished gathering was the result, the chef surpassed himself (or herself—does a ladies' club submit to a male chef?), toasts were drunk, speeches both witty and serious were made, and all went merrily.

Thanks and congratulations are due to the hospitable ladies of the Forum Club.

Mr. H. O. Short on "Rings"

SPEAKING at the annual general meeting of Short Bros. (Rochester and Bedford), Ltd., in London last week, Mr. H. O. Short (the chairman) said he thought it advisable to refer to "Statements which have appeared in certain sections of the Press and to questions which have occasionally been asked in Parliament, all of which are intended to imply that there is a 'ring' of aircraft constructors exacting high profits from the Government. It cannot be too definitely stated that no such 'ring' exists.

"The Government places orders for aircraft and aircraft parts where it wishes," continued Mr. Short, "and many new companies are now receiving such orders. Moreover, in all contracts placed for aircraft armament there is a strict investigation of costs and the profit considered permissible is also fixed; and I may say that it is very low.

"One newspaper has stated that our profits on our issued capital is 82 per cent. this year. In making that calculation the writer of the article appears to have overlooked the value of our share premium and reserve accounts and other assets usefully employed in the business.

"Our issued capital is small in relation to our assets, which were built up many years before we became a public company. From 1916 to 1935 none of our shareholders received a dividend. All profits made were ploughed back into the business and spent on land, plant and buildings to maintain our works as a going and growing concern.

"In that way we built up a great aircraft factory which in these serious times is an important national asset. Also we kept together a large staff and a large number of men in employment on aircraft work, and their past experience is now invaluable to the country. The satisfactory state of our balance sheet to-day is due to our earning a small margin of profit on a very large turnover."

Reviewing the year's progress, Mr. Short said that in addition to the orders on hand for military aircraft, they still had considerable orders for commercial aircraft, including new flying boats for transatlantic services; also they had been favoured by the Air Ministry with an order for three large passenger aeroplanes of a very advanced type and one of which was for high-altitude flying.

Great progress had been made at the associated Belfast works of Short and Harland, Ltd., which was now in active production.

He was sure that his hearers would be pleased to learn that Mr. Arthur Gouge had been appointed managing director of both this and the other subsidiary company, Pobjoy Airmotors and Aircraft, Ltd.

Sub-contract Celebration

MORE than seventy employees and guests attended the first annual dinner held by R. Malcolm, Ltd., on November 25. Mr. G. Shea was in the chair. In his reply to the toast of the directors, Mr. Ronnie Malcolm thanked those who had helped to get the firm going and, in particular, Mr. G. Rixon, the works manager. After the dinner a cabaret was put on by the brother of the second of the two directors, Mr. Farquarson.

A Sheet-metal Festivity

AT the staff dinner of H. and A. Williamson and Co., Ltd., of Edmonton (a growing firm which supplies tanks to Hawker, Gloster, Vickers-Armstrong and other constructors), it was pleasant indeed to observe the high esteem in which the staff of this company hold their joint managing directors, Messrs. "Billy" and Arthur Williamson. One of their co-directors, Mr. G. W. Higgs, mentioned that there was not a job in the works which the two brothers could not do—a remark which was drowned in an understanding burst of applause.

Mr. Higgs, telling the story of the firm's growth, said that in 1936 it had 25 hands on its books. Now it had 190, and by the time the new works were completed next year they hoped to employ 350.

Newcastle United

AN unusual kind of dinner was held last week in Newcastle. Five Tyneside structural steel engineering companies, normally business rivals in direct competition with one another, had decided that too many contracts were passing over their heads on the way north or south as the case might be. Moreover, even local contracts were being handled outside. Convinced that they were being overlooked because many architects and builders did not realise that Tyneside could do the work just as well, possibly even better, the five firms decided to collaborate by holding a dinner so that prominent northern architects, builders and contractors could be invited to meet, in pleasant surroundings, representatives of the Tyneside structural engineering firms. The firms concerned were Wright, Anderson and Co., Ltd. (constructors, among other things, of aerodrome hangars, aircraft factories, etc.), Palmers Heburn Co., Ltd., James W. Ellis and Co., Ltd., Robert Frazer and Sons, Ltd., and George M. Carter (Erectors), Ltd.

The dinner was held in the beautiful Old Assembly Rooms at Newcastle. Before a company of some 200 representatives and guests Mr. J. E. Hodgkin, chairman of Wright, Anderson and Co., Ltd., explained the purpose of the occasion and told, incidentally, how Scotland had come over the Border and actually taken away contracts from Newcastle. Work placed on the Tyneside would bring an 80 per cent. return to the district in value in wages.

Mr. T. E. Milburn, a leading architect, concurred, and said that those in the North should be a little more clannish and keep all the work in the North.

Publisher's Announcement

THE Christmas holiday makes it necessary for small advertisements intended for *Flight* of December 29 to be in our hands not later than first post on Friday, December 23.